“THE SPECTRUM OF CARDIAC DISORDERS IN INFANTS OF DIABETIC MOTHERS”

Dissertation submitted in partial fulfilment of the

Requirement for the award of the Degree of

DOCTOR OF MEDICINE - BRANCH VII

PAEDIATRIC MEDICINE

APRIL 2015

TIRUNELVELI MEDICAL COLLEGE HOSPITAL

THE TAMIL NADU DR.M.G.R. MEDICAL UNIVERSITY

CHENNAI ,

TAMIL NADU.

CERTIFICATE

This is to certify that the Dissertation entitled **"THE SPECTRUM OF CARDIAC DISORDERS IN INFANTS OF DIABETIC MOTHERS" - A Study In Patients Admitted In Tirunelveli Medical College Hospital** is the bonafide work of **Dr. S. BRINDHA** in partial fulfilment of the requirements for the degree of Doctor of Medicine in Paediatrics Examination of The Tamil Nadu Dr. M.G.R. Medical University to be held in April 2015.

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DECLARATION

I**, Dr. S. BRINDHA M.B.B.S**, solemnly declare that the Dissertation titled **"THE SPECTRUM OF CARDIAC DISORDERS IN INFANTS OF DIABETIC MOTHERS" - A Study In Patients Admitted In Tirunelveli Medical College Hospital** is a bonafide work done by me at the Department of Paediatric, Tirunelveli Medical College Hospital, under the guidance and supervision of **Dr.M.GEETHANJALI MD., Professor Tirunelveli Medical College Hospital, Tirunelveli.**

The Dissertation is submitted to the Tamilnadu Dr.M.G.R. Medical University, Chennai, in partial fulfillment of the regulations for the award of MD Degree Branch VII (PAEDIATRICS).

It was not submitted to the award of any degree/diploma to any University either in part or in full previously.

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CERTIFICATE OF REGISTRATION & APPROVAL OF THE TIREC REF NO: 483/PAED/2013/33

PROTOCOL TITLE: Spectrum of Cardiac Disorders in infants of Diabetic Mothers

NAME OF PRINCIPAL INVESTIGATOR: Dr. S.Brindha
DESIGNATION OF PRINCIPAL INVESTIGATOR: Resident in Paediatrics
DEPARTMENT & INSTITUTION: Department of Paediatrics, Tirunelveli Medical College

Dear Dr. S.Brindha, *The Tirunelveli Medical College Institutional Ethics Committee (TIREC) reviewed and discussed your application during the IEC meeting held on 28.12.13.*

THE FOLLOWING DOCUMENTS WERE REVIEWED AND APPROVED

1.	TIREC Application Form	☑
2.	Study Protocol	☑
3.	Department Research Committee Approval	☑
4.	Patient Information Document and Consent Form in English and Vernacular Language	☑
5.	Investigator's Brochure	☐
6.	Proposed Methods for Patient Accrual Proposed	☑
7.	Curriculum Vitae of the Principal Investigator	☑
8.	Insurance /Compensation Policy	☑
9.	Investigator's Agreement with Sponsor	☐
10.	Investigator's Undertaking	☑
11.	DCGI/DGFT approval	☐
12.	Clinical Trial Agreement (CTA)	☐
13.	Memorandum of Understanding (MOU)/Material Transfer Agreement (MTA)	☑
14.	Clinical Trials Registry-India (CTRI) Registration	☐

THE PROTOCOL IS APPROVED IN ITS PRESENTED FORM ON THE FOLLOWING CONDITIONS

1. The approval is valid for a period of 2 year/s or duration of project whichever is later
2. The date of commencement of study should be informed
3. A written request should be submitted 3weeks before for renewal / extension of the validity
4. An annual status report should be submitted.
5. The TIREC will monitor the study
6. At the time of PI's retirement/leaving the institute, the study responsibility should be transferred to a person cleared by HOD
7. The PI should report to TIREC within 7 days of the occurrence of the SAE. If the SAE is Death, the Bioethics Cell should receive the SAE reporting form within 24 hours of the occurrence.
8. In the events of any protocol amendments, TIREC must be informed and the amendments should be highlighted in clear terms as follows:
   a. The exact alteration/amendment should be specified and indicated where the amendment occurred in the original project. (Page no. Clause no. etc.)
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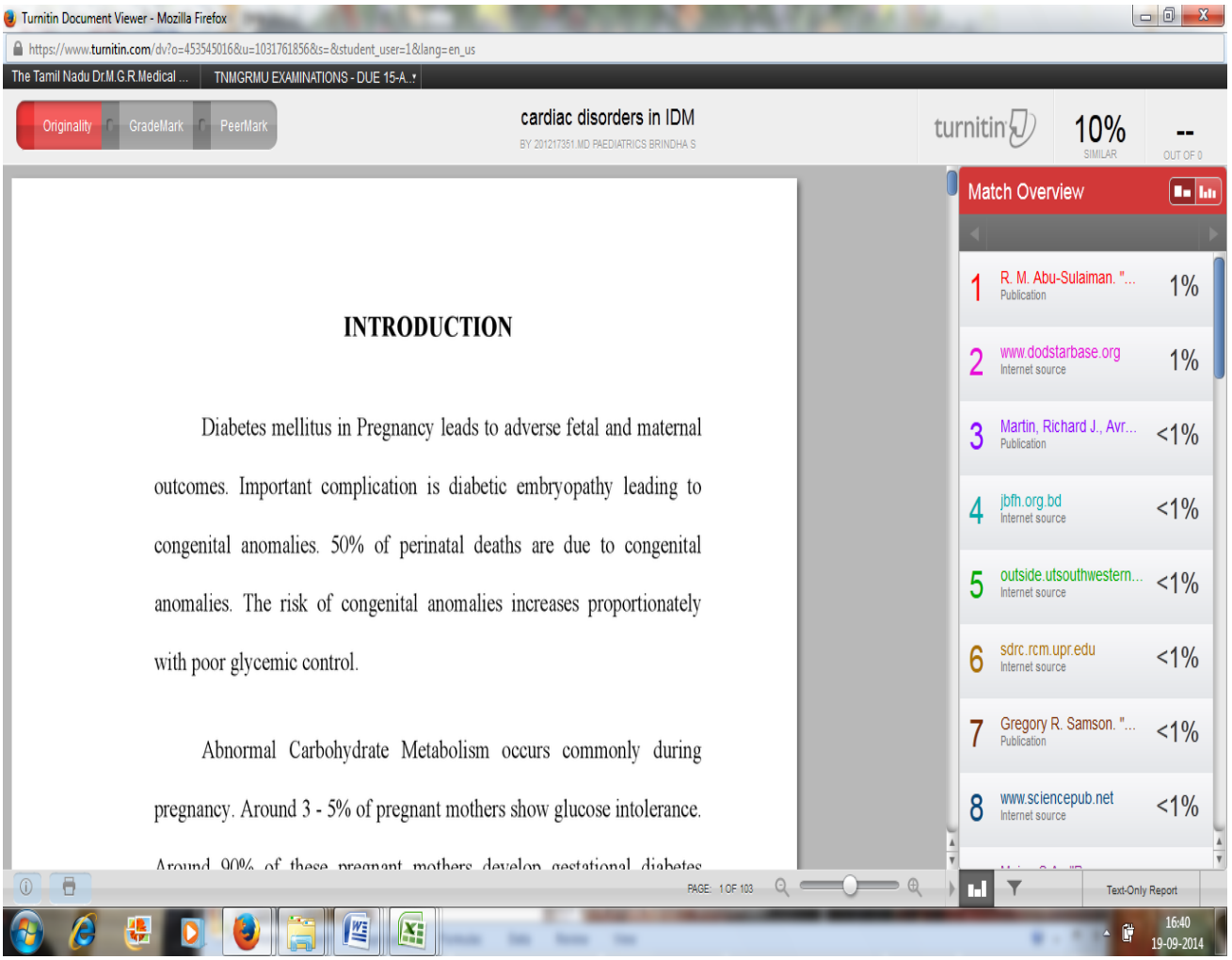
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INTRODUCTION
Diabetes mellitus in Pregnancy leads to adverse fetal and maternal outcomes. Important complication is diabetic embryopathy leading to congenital anomalies. 50% of perinatal deaths are due to congenital anomalies. The risk of congenital anomalies increases proportionately with poor glycemic control.
Abnormal Carbohydrate Metabolism occurs commonly during pregnancy. Around 3 - 5% of pregnant mothers show glucose intolerance.
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CONTENTS

ABBREVIATIONS

AGA	-	Appropriate for Gestational Age
ASD	-	Atrial Septal Defect
COA	-	Coarctation of Aorta
CNS	-	Central Nervous System
CBG	-	Capillary Blood Glucose
DM	-	Diabetes Mellitus
ECG	-	Electrocardiography
Echo	-	Echocardiography
FBS	-	Fasting Blood Sugar
GDM	-	Gestational Diabetes Mellitus
GCT	-	Glucose Challenge Test
HOCM	-	Hypertrophic Obstructive Cardiomyopathy
IDDM	-	Insulin Dependent Diabetes Mellitus
IUD	-	Intrauterine Death
LGA	-	Large for Gestational Age
LN	-	Labour Naturalise
LSCS	-	Lower Segment Caesarean Section
NICU	-	Neonatal Intensive Care Unit
OGTT	-	Oral Glucose Tolerance Test

PPBS	-	Postprandial Blood Sugar
PDA	-	Patent Ductus Arteriosus
PFO	-	Patent Foramen Ovale
PPHN	-	Persistent Pulmonary Hypertension
RDS	-	Respiratory Distress Syndrome
SGA	-	Small for Gestational Age
TA	-	Truncus Arteriosus
TGV	-	Transposition of Great Vessels
TOF	-	Tetrology of Fallot

ABSTRACT

Title of the Study

THE SPECTRUM OF CARDIAC DISORDERS IN INFANTS OF DIABETIC MOTHERS.

Aim of the Study

- The objective of the study is to identify neonates born to gestational diabetes mellitus, type - 1 and type - 2 mellitus and to detect the spectrum of congenital heart diseases manifested by them.

Type of Study

Prospective observational study

Study period

Between January 2014 to June 2014 a prospective study of 50 consecutive infants of diabetic mothers admitted at Tirunelveli Medical College Hospital was under taken.

Study Population

All infants of diabetic mothers admitted in neonatal intensive care unit in Tirunelveli Medical College Hospital were included in the study.

Sample Size

50 consecutive infants of diabetic mothers admitted in neonatal intensive care unit in Tirunelveli Medical College Hospital.

Inclusion Criteria

All live born infants of mothers with gestational diabetes mellitus, type 1 insulin dependent diabetes mellitus, type 2 non insulin dependent diabetes mellitus.

Exclusion Criteria

- Infants of diabetic mothers with severe hypoxic ischemic encephalopathy.
- Mothers with TORCH infections.
- Mothers with systemic lupus erythematosus
- Mothers on teratogenic cardiotoxic drugs
- Babies with other syndromic anomalies.

Method of Study

- Infants of diabetic mellitus will be evaluated in the first 10 days of life by detailed clinical examination with special reference to cardiovascular system.
- Chest X-ray
- Electrocardiogram
- Echocardiography

All the above mentioned investigations will be done after obtaining informed consent from the mothers.

Observation

Among the 50 cases studied 27 were male and 23 were female. Among the 50 diabetic mothers 90% of mothers were booked and treated, 10% of mothers were unbooked and not treated. Among the mothers included in this study 84% had GDM and 16% had pregestational DM. Among the diabetic mothers 60% were given insulin and 30% were on meal plan. Among the treated mothers 60% were compliant and 30% were non- compliant.

Results

Among the 50 infants studied 30% had congenital heart diseases of which acyanotic congenital heart diseases accounted for 26% and cyanotic congenital heart diseases accounted for 4%. Among the IDM babies 12% had clinical manifestations, radiological findings and 10% had electrocardiographic findings. 30% of IDM babies had echocardiographic findings. The congenital heart diseases observed in this study include

Heart Disease	Frequency	Percentage
HOCM	5	10%
PFO	2	4%
ASD	2	4%
VSD	2	4%
PDA	2	4%
TOF	1	2%
TGV	1	2%
Negative	35	70%

Inference

Untreated mothers had more number of infants with congenital heart diseases than treated mothers.

Cases which were not detected by clinical examination, radiological investigation, and electrocardiography were detected by echocardiography.

- Clinical manifestations were positive in 56.4% of the cases with congenital heart disease.

- Radiological investigations were positive in 56.4% of the cases with congenital heart disease.
- Electrocardiographic findings were positive in 50.9% of the cases with congenital heart disease.
- Echocardiography was positive in 100% of the cases with congenital heart disease.

Echocardiography remains the gold standard investigation for the diagnosis of congenital heart diseases in infants of diabetic mother.

Hence all infants of diabetic mother must undergo echocardiographic investigation before their discharge for earlier diagnosis and appropriate management of congenital heart diseases.

Infants of diabetic mother must undergo echocardiography as a routine as early as possible.

Earlier recognition, precise assessment of the cardiac status and appropriate management of cardiac complications might reduce both the morbidity and mortality among babies born to diabetic mothers.

KEY WORDS : CONGENITAL HEART DISEASES, IDM

1. INTRODUCTION

Diabetes mellitus in Pregnancy leads to adverse fetal and maternal outcomes. Important complication is diabetic embryopathy leading to congenital anomalies. 50% of perinatal deaths are due to congenital anomalies. The risk of congenital anomalies increases proportionately with poor glycemic control.

Abnormal Carbohydrate Metabolism occurs commonly during pregnancy. Around 3 - 5% of pregnant mothers show glucose intolerance. Around 90% of these pregnant mothers develop gestational diabetes mellitus.

1.1. In Pregnancy diabetes Mellitus is classified as:

* Pre gestational diabetes mellitus
* Gestational diabetes mellitus

Gestational Diabetes Mellitus is Carbohydrate intolerance which is first diagnosed in pregnancy. Its incidence is around 3 - 5% of all pregnancies. Congenital anomalies occur commonly in the first trimester of pregnancy due to poor glycemic control.

Ideally management of diabetes mellitus should begin prior to conception. Women with gestational diabetes mellitus have 60% life time

risk of developing overt type 2 diabetes mellitus. Management includes watchful monitoring and treatment during antenatal period, during delivery.

Tests to be done in diabetic mothers during pregnancy:

1.2. Screening in mothers with diabetes mellitus.

1.2.1. Ist Trimester

- Glycosylated Haemoglobin
- Ultra Sonogram
- Renal function test
- Opthalmic examination
- Thyroid profile

1.2.2. **IInd Trimester**

- Fetal Echocardiography
- Serum testing for neural tube defects
- For high risk cases Chorionic villi sampling and amniocentesis has to be done.

1.2.3. IIIrd Trimester

- Monitoring of Fetal growth by monthly Ultra Sonogram.
- Weekly fetal Monitoring by - Non stress test.
  - Biophysical profile.

Good Glycemic control can be achieved through

- Proper Dietary modifications
- Exercise
- Medications

1.3. Objectives of Treatment:

- To maintain fasting capillary blood glucose less than 95 mg/dl.
- 1st hour postprandial capillary blood glucose less than 140 mg/dl.
- 2nd hour postprandial capillary blood glucose less than 120 mg/dl.

Human Insulin analogues do not cross the placenta. Owing to their teratogenicity administration of insulin therapy to maintain euglycemia in pregnancy is mandatory. Glycemic control in the previous 3 months can be monitored by the level of glycosylated haemoglobin.

Antenatal steroids used for fetal lung maturity can further aggravate hyperglycemia in the pregnant women. Early administration of insulin therapy in hyperglycemic mothers protects the neonate from developing metabolic complications and major congenital anomalies.

Maternal diabetes mellitus is a significant risk factor for the development of congenital heart diseases.

In mothers with gestational diabetes mellitus, type 1 and type 2 diabetes mellitus labour can be planed around 39 - 40 weeks of gestation unless other complications intervene in the course of pregnancy. Continuous fetal monitoring should be done during the process of labour. Mode of delivery can be planned by ultrasonogram estimated fetal weight, maternal and fetal conditions with previous obstetric complications.

During labour blood glucose concentration should be monitored every 1^{st} or 2^{nd} hourly. Glucose concentration greater than 120 - 140 mg/dl can be treated with short acting insulin which is given as an infusion.

Lactation leads to significant hypoglycemia in the post partum period. This acts as a honeymoon period. Women with gestational diabetes mellitus become euglycemic in the post partum period. Women with type 2 diabetes mellitus can be treated with metformin or glyburide in the post partum period.

Careful evaluation and early diagnosis of congenital anomalies in high risk group are highly indicated. It is high time for us to develop perinatal screening programs for congenital heart diseases in our population.

Newborns should be screened for major congenital anomalies. Examination of the placenta should also be carried out. Special attention should be paid for checking vitals like heart rate, respiratory rate, temperature, color, perfusion and blood pressure. Cardio vascular system genitourinary system, central nervous system should be given special attention during screening.

2. AIM OF THE STUDY

To study the spectrum of heart diseases in newborns born to diabetic mothers.

To emphasize the significance of strict glycemic control during pregnancy in mothers with gestational diabetes mellitus, type - 1 and type 2 diabetes mellitus.

To emphasize the necessity to monitor the babies born to diabetic mothers in their very early neonatal period, to recognise the complications early and treat them.

To emphasize the necessity of cardiac evaluation with echocardiogram in the early neonatal period in all infants of diabetic mothers and to establish the diagnosis of heart diseases which presents without much clinical manifestations.

3. REVIEW OF LITERATURE

Diabetes Mellitus is a disorder of abnormal glucose metabolism which complicates around 1% of total pregnancies making it almost the most common endocrine disorder that occurs during pregnancy. In pregnancy diabetes mellitus leads to abnormal complications in both mother and neonate. Advanced planning is essential if one wants a baby without diabetes mellitus induced complications [1,2].

There has been reduction in the mortality and morbidity of neonates born to diabetic mothers due to the recent advancement in treatment modalities of diabetes mellitus during pregnancy. The perinatal mortality rate is around 3 - 5% where as in the general population the perinatal mortality rate is low to the level of 1 - 2%. The incidence of complications like macrosomia, hypoglycemia, hypocalcemia, hyper bilirubinemia, polycythemia, respiratory distress syndrome, congenital malformations and birth injuries are frequent in neonates born to diabetic mothers.

The complications can be decreased by maintaining good glycemic control in diabetic mothers and the higher perinatal mortality rates can be reduced.

3.1. INCIDENCE OF DIABETES MELLITUS

The overall incidence of diabetes mellitus is around 3 - 10% of all total pregnancies. Among them gestational diabetes mellitus occur around 90% of diabetes cases complicating pregnancy[2]. Mothers with gestational diabetes mellitus are persons who have a strong genetic or metabolic pre disposition towards diabetes and or not able to counteract the diabetogenic changes that occur commonly during pregnancy. Type - 2 diabetic mellitus occurs around 8% of all cases of diabetes mellitus complicating pregnancy.

Recently the prevalence of gestation diabetes mellitus has increased to around 10 - 100%. The increasing prevalence of gestational diabetes reflects the pattern of increased diabetes and obesity in children in recent years. Screening and management of mothers with gestational diabetes, type 1 and type 2 diabetes mellitus to achieve a good glycemic control are essential for helping in future. The complications that occur during and after pregnancy can be minimized by maintaining proper euglycemic levels.

3.2. Physiology :

As such pregnancy is a diabetogenic state. This occurs due to the hormonal changes that occur during pregnancy. The striking change is the insulin resistance that occurs during pregnancy. Hyperglycemic state is

predisposed by the increased placental hormonal levels. Human placental lactogen is increased during the 3rd trimester of pregnancy. That is why gestational diabetes mellitus occurs more often after 26 weeks of gestation [2,4].

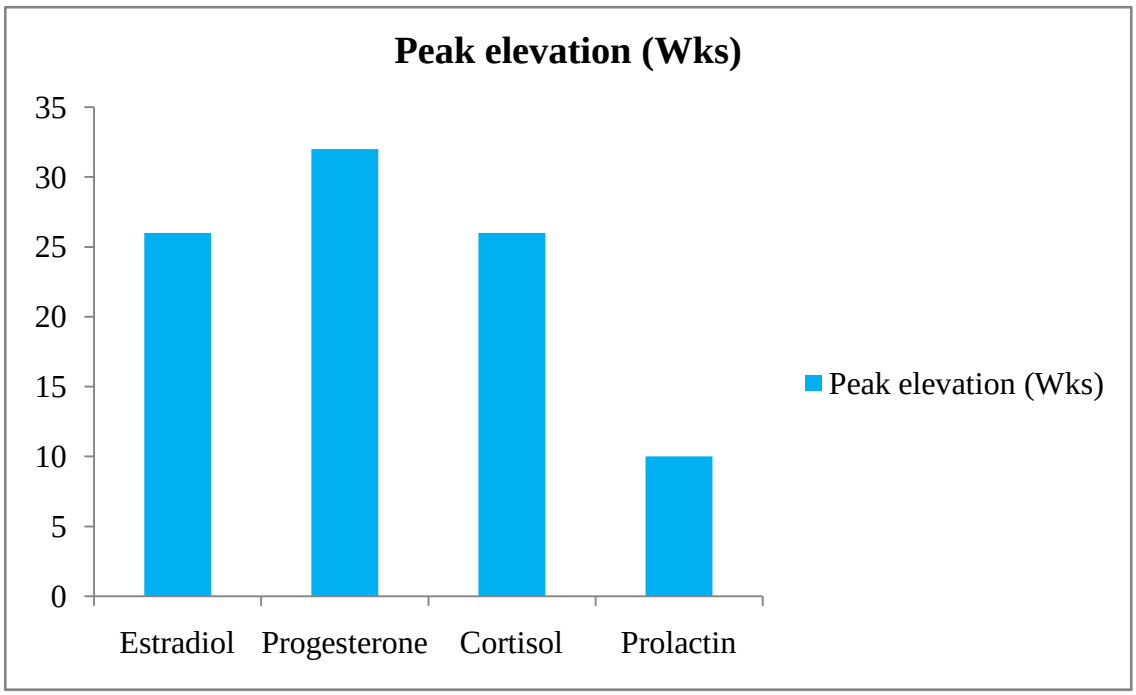
3.3. Carbohydrate Metabolic changes during pregnancy :

Owing to the hormonal changes that occur commonly during pregnancy carbohydrate metabolism also undergoes very many changes. Pregnancy increases the diabetogenic tendency of pregnancy. This is due to the progressive increase in insulin resistance that occurs during pregnancy. Increased diabetogenic tendency occurs due to changes in gluconeogenesis and lipolysis that occurs during pregnancy [2,4,5]. In the earlier periods of pregnancy the sensitivity to insulin is increased, the patients are more prone for increased incidence of hypoglycemia. The insulin sensitivity is attributed to the high level of estrogen. From 10 - 16 weeks of gestation fasting blood sugar level is usually lower than normal. Later the blood sugar value rises up gradually upto 32 weeks of gestation.

Hyperglycemia in 3rd trimester is attributed to the increased insulin resistance that occurs in later period of gestation. Higher level of human placental lactogen is the reason behind insulin resistance that occurs in the latter half of pregnancy[5].

DIABETOGENIC HORMONES IN PREGNANCY

Hormone	Peak elevation (Wks)	Diabetogenic Potency
Estradiol	26	Very weak
Progesterone	32	Strong
Cortisol	26	Very Strong
Prolactin	10	Weak



This explains the higher incidence of gestational diabetes mellitus after 26 weeks of gestation.

3.4. Effects of Diabetes on Pregnancy:

Commonly carbohydrate imbalance is asymptomatic and goes unnoticed in pregnancy. In women with microalbuminuria, worsening of microalbuminuria occurs and they are at an increased risk of preeclampsia. The risk is increased to the range of 10 - 25% [2,3,15].

The risk of chorioamnionitis and postpartum endometritis rises significantly in pregnancies complicated by diabetes mellitus.

Diabetic gastroparesis exacerbates hyperemesis gravidarum which is a normal variant in pregnancy. Hence, Diabetic mothers have to be provided with extra nutritional support [2].

Diabetic Retinopathy can occur as a new complication or the already existing retinopathy can worsen during the course of pregnancy. Mothers with pre existing renal disease are at increased risk of further deterioration of renal functions further during the course of pregnancy. Post partum haemorrhage occurs due to exaggerated uterine distension.

The incidence of hyperglycemia, hypoglycemia and Ketoacidosis are also common. Ketoacidosis leads to poor neurological outcome and poor cognition in the new born. Mother may develop Coronary artery disease and thromboembolic complications.

3.4.1. Adverse effects of diabetes on pregnancy [3,6]

- ❖ Increased insulin is essential for achieving good glycemic control .
- ❖ Diabetic retinopathy can progress leading to visual impairment in later stages.
- ❖ Diabetic nephropathy can worsen leading to renal failure in later stages.
- ❖ Increased rate of death for pregnant mother with diabetic cardiomyopathy.

Diabetic mothers have abnormal tendency for metabolic instability and they require frequent blood glucose monitoring. They also require continuous adjustment in treatment modality and they require a regulated life pattern. For diabetic mothers who have prior organ damage pregnancy may lead to end organ disease leading to intensive care and therapeutic interventions.

The abnormal interaction between altered carbohydrate metabolism and pregnancy must be explained to each pregnant mother clearly soon after the diagnosis is made or even before planning of conception. Maintaining euglycemia in the pregnant mother leads to decreased complications in the fetus and in the new born period.

3.4.2. Diabetes mellitus classification in pregnancy :

Pregestational can be classified as

- Type – 1
- Type - 2

Gestational diabetes mellitus can be classified as [11]

- Diet controlled
- Insulin requiring

Type - 1 Diabetes Mellitus :

Diabetes mellitus type – 1 is a condition where in the body produces no insulin or decreased insulin so that the body cannot convert blood glucose in to energy. It occurs commonly during childhood or early adolescence.

Type - 2 Diabetes Mellitus :

Diabetes mellitus type - 2 is a condition where body makes too little insulin or it is unable to use the insulin which it produces to change blood glucose in to energy. This occurs mostly in child bearing age.

Gestational Diabetes Mellitus:

Diabetes mellitus is first diagnosed during pregnancy and usually resolves after pregnancy.

WHITE'S classification of diabetes mellitus

Class A1	-	GDM, which is diet controlled
Class A2	-	GDM, which is mediation control
Class B	-	Age of onset >20 years duration years <10 years
Class C	-	Onset at 10 – 19 years duration 10 – 19 years
Class D	-	Onset before 10 years duration >20 years
Class E	-	Overt diabetes mellitus with calcified pelvic vessels
Class F	-	Diabetic nephropathy
Class R	-	Diabetic Retinopathy
Class RF	-	Nephropathy with Retinopathy
Class H	-	Ischemic heart disease
Class T	-	Prior renal transplant

The Classification is named after PRISCILLA WHITE who has done immense work on the effect of diabetes mellitus on fetal outcome and it is used as an assessment tool for maternal and fetal risk.

3.4.3. Risk Factors for Gestational Diabetes Mellitus :

- Obesity
- Age >30 years
- History of gestational Diabetes mellitus in prior pregnancy
- History of Large for gestational age baby during previous pregnancy.
- Family history with type 2 Diabetes mellitus
- Elderly Primigravida
- Higher dietary fat and low fiber diet during pregnancy

3.4.4. Screening for Gestational Diabetes Mellitus :

- Done for high risk pregnancies
- Done using glucose tolerance test and glucose challenge test

3.4.5. Glucose tolerance test

Done using 50 grams glucose without any regard to time of day, previous meal, done between 24 – 28 weeks of gestation. Plasma glucose level of 140 mg% or whole blood glucose of 130mg% at 1 hour is the cutoff point for doing 75gram glucose tolerance test. Diagnosis of gestational diabetes mellitus is based upon 75gram glucose tolerance test. A larger glucose load is advised because there is an increased turnover of glucose during pregnancy[12].

Indication for Glucose tolerance test :

- Following a positive screening test.
- Fasting glycosuria on a single occasion prior to 20 weeks of gestation and 2 or more occasions later on.
- Random blood glucose >95 mg / 100 ml.

If fasting blood sugar >126 mg/dl, if confirmed by repeat test GTT need not be performed.

Methodology

Patient is advised to come with 8 hours of fasting. Before beginning the procedure a blood sample is done which gives the fasting blood sugar level. The patient is then asked to consume about 75 grams of sugars and 3 more blood glucose samples are taken at 1^{st} hour, 2^{nd} hour and 3^{rd} hours respectively.

Result interpretation

- Normal value – Fasting blood glucose 60 – 100 mg/dl
- 1 hour blood glucose value <200 mg/dl
- 2 hour <140 mg/dl

Glycosylated Haemoglobin (HbA1C) is a test to determine the level of haemoglobin that is coated with sugar. HbA1C value shows the

glycemic control for the previous 4 - 6 weeks. HbA1C level >7 indicates hyperglycemia during the previous 4 – 6 weeks.

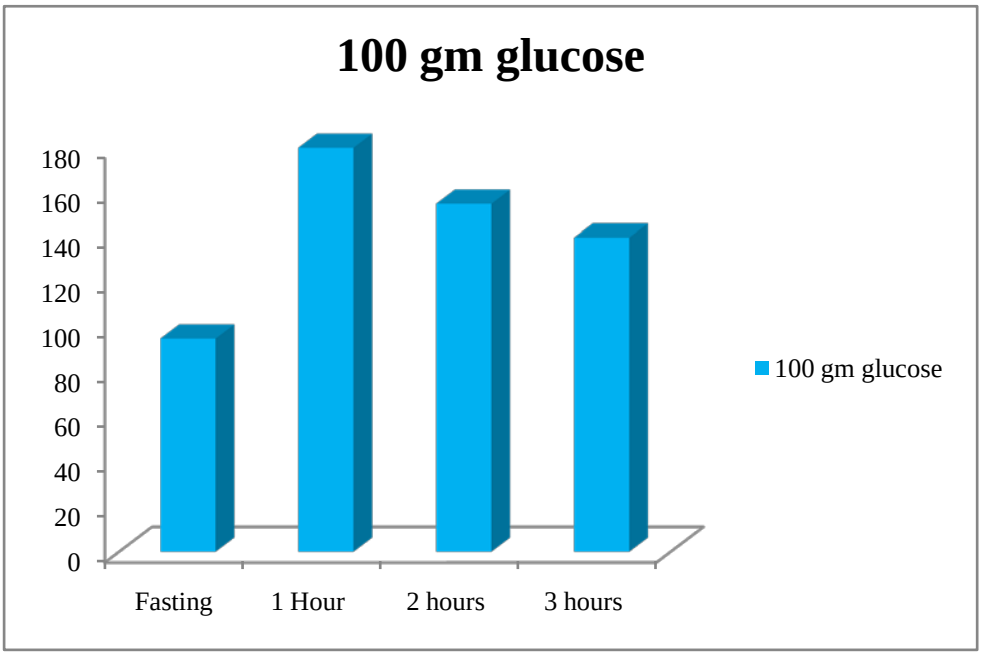
Diagnostic Criteria for Diabetes mellitus prior to pregnancy:

- Random blood sugar level >200 mg/dl with symptoms of diabetes mellitus.
- Fasting blood sugar level >126 mg/dl
- 2 hour postprandial blood sugar >200 mg/dl using oral glucose tolerance test.

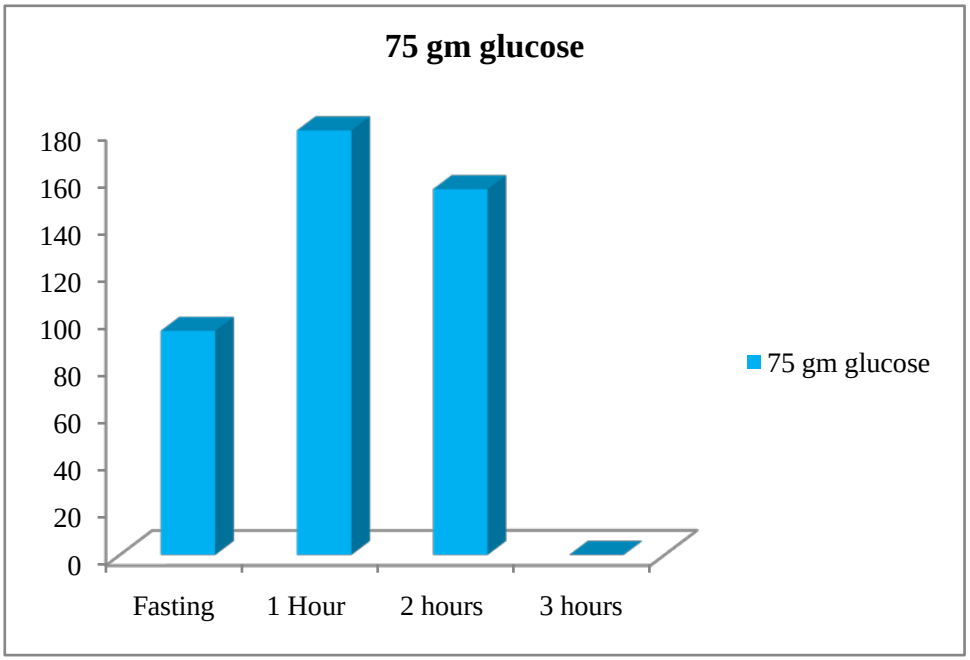
3.4.6. Diagnostic criteria for gestational diabetes mellitus[13]

	100 gm glucose	**75 gm glucose**
Fasting	95 mg/dl	95 mg/dl
1 Hour	180 mg/dl	180 mg / dl
2 hours	155 mg/dl	155 mg/dl
3 hr	140 mg/dl	---

100 Gram Glucose Tolerance Test



75 Gram Glucose Tolerance Test



3.5. Complications in infants of diabetic mothers

- Miscarriages
- Still Birth
- Macrosomia
- Preterm Labour
- Birth Injuries
- Birth Asphyxia

3.5.1. Metabolic complications like

- Hypoglycemia, Hypocalcemia, Polycythemia, Hyperbilirubinemia can occur.
- Respiratory distress syndrome occurs due to lack of combination between lecithin and choline.

3.5.2. Structural birth defects like

Neural tube defects, Holoprocencephaly, Sacral agenesis.

Cardiovascular

Hypertrophic cardiomyopathy, transposition of great vessels Coarctation of Aorta, Patent ductus arteriosus, atrial septal defect, ventricular septal defect, Single Ventricle, patent foramen ovale, tetrology of fallot can occur.

Renal: Hydronephrosis, Renal agenesis.

GIT: Lazy left colon syndrome, duodenal atresia.

Caudal regression syndrome can also occur.

Maternal Hyperglycemia leads to fetal hyperglycemia. Fetal hyperglycemia stimulates fetal islet cells of pancreas leading to hyper insulinnemia. Fetal hyperinsulinemia is the prime cause for fetal macrosomia, metablic complications.

3.5. Fetal Macrosomia:

Fetal Macrosomia is fetal weight equal to or more than 4 Kg. Macrosomia could be the common cause for increased incidence of cesarean section, birth injuries like fracture clavicle, Erb's palsy, Klumpkes paralysis occurring as a result of shoulder dystocia [2,7,8].

Macrosomia occurs due to raised 3rd trimester maternal blood sugar level. All pregnant diabetic mothers must undergo ultrasonogram examinations once in every 4 weeks from 20 weeks of gestation to assess the fetal weight gain. The first external marker is an abnormal increase in abdominal circumference.

For fetal weight >4kg caesarean section is advised to prevent complications resulting from birth injuries. Macrosomic babies must be

admitted and observed for metabolic complications and congenital structural abnormalities.

Hypoglycemia [2,6,10] is seen in around 25 – 40% of babies born to mothers with diabetes mellitus. Blood glucose level <40mg/dl is termed as hypoglycemia. It occurs due to increased insulin secretion by hypertrophied islet cells of pancreas due to maternal hyperglycemia, which leads to fetal hyperglycemia which in turn stimulates fetal islet cells.

Hypocalcemia [10] accounts for 25 - 30% of babies born to mother with diabetes mellitus. Ionised calcium level <4mg/dl is termed as hypocalcemia. Total calcium level <7mg/dl can also be termed as hypocalcemia.

Polycythemia [7, 8] occurs in 30 - 32% of infants of diabetic mothers. Chronic fetal hypoxia results in polycythemia. Venous hematocrit >65% is termed as polycythemia.

Hyperbilirubinemia[2] occurs in 20 – 25% of infants of diabetic mothers.

Respiratory distress syndrome[10] occurs in 3 - 5% of infants of diabetic mothers. Measurement of phosphatidyl glycerol, lecithin,

phosphatidyl Choline are used as reliable indicators for fetal lung maturity in infants of diabetic mothers.

Treatment guidelines for diabetes mellitus complicating pregnancy [2,9].

- Evaluation of blood glucose levels.
- Evaluation of blood pressure
- Evaluating renal function
- Opthalmic evaluation for retinal status
- Electrocardiogram
- Clinical evaluation of hypoglycemic symptoms
- Clinical evaluation of autonomic and peripheral neuropathies
- Clinical evaluation for peripheral vascular diseases

General risks and treatment modalities should be explained to the expectant mothers.

Periconceptional Folate supplementation around 5 mg / day for atleast 2 months prior to conception and during first trimester of gestation minimizes the risk of neural tube defects in infants of diabetic mothers.

Euglycemia reduces the risk of metabolic complications and structural abnormalities that commonly occurs in infants of diabetic mothers.

3.6. Antenatal screening of diabetes mellitus [14] :

- Screen for gestational diabetes mellitus in all pregnancies.
- Regular capillary blood glucose monitoring
- Appropriate diet
- Advisable exercises
- Avoiding oral hypoglycemic agents as they are teratogenic.
- Obtaining euglycemia through insulin therapy in hyperglycemic patients.
- Regular ophthalmic screening with nephrologic screening.
- Monitoring of blood pressure
- Monitoring of fetal well being.

3.7. Test for fetal well being

- Counting of fetal movements from 28 weeks of gestation. Fetal movements >10/60 min is reassuring.
- Ultrasonogram biophysical profile to be done weekly
- Non - stress test done twice weekly after 28 – 34 weeks of gestation. Two heart rate acceleration in <20 min is reassuring.
- Contraction stress test to be done weekly. Nil heart rate deceleration in response to <3 contractions in 10 minutes.

3.8. Planning of Labour

- Can be delayed till term if euglycemia is achieved and no obstetric complications intervene.
- Fetal and maternal complications controls mode of delivery.

3.9. Postnatal period

- Continue blood glucose monitoring.
- Encourage active breast feeding
- Insulin requirement grossly decreases in the postnatal period.

Advantages of Breast Feeding

- Improved pancreatic beta cell function
- Improved metabolism of glucose
- Non – insulin mediated glucose utilization by mammary glands to synthesize lactose.
- Improved lipid metabolism
- Improved insulin sensitivity due to increased levels of prolactin and decreased levels of estradiol.

3.10. Management of diabetes mellitus in pregnancy

Ensuring euglycemia remains the main target during the antenatal period.

3.10.1. Dietary Management

Meal plan which maintains euglycemia should be administered [2]. Dietary constitution should include carbohydrate 50%, protein 20%, fat 25%, which includes <10% saturated fat.

3.10.2 Insulin therapy

If postprandial blood sugar level >150 mg/dl in addition to meal plan insulin has to be given subcutaneously in divided doses titrating the blood sugar levels. Insulin administered depends upon blood sugar levels.

- Fasting blood sugar level should be <95mg/dl.
- Postprandial blood sugar level at 1 hour <140 mg/dl
- Postprandial blood sugar level at 2 hours <120 mg/dl

Blood glucose monitoring to be done every 2 - 4 hours in early labour, every 1 – 2 hours in active labour. For patients on insulin therapy regular insulin should be given as infusion.

3.10.3. Post Partum Period

Insulin resistance decreases immediately after the delivery of the placenta. Insulin requirement may decrease in the next 24 – 48 hours. If blood glucose level rises insulin has to be re-administered using half to 2/3 of the value of previous administration.

Maternal diabetes mellitus is a significant risk factor for congenital heart diseases. Careful evaluation and early diagnosis of heart diseases in high risk group are highly indicated. It is high time for us to develop perinatal screening programs in our population.

Hypertrophic obstructive cardiomyopathy appears most commonly in infants of diabetic mothers with severe hyperinsulinisn. Routine echocardiogram of at risk newborns should be considered. Cardiac malformations are five times higher than in normal pregnancies. Insulin like growth factor is the predominant factor behind this. Diagnosis should be confirmed through echocardiography as the management may vary with each diagnosis. Digoxin or Ionotropic agents which may be used in heart failure associated with structural heart defects are contraindicated in hypertrophic obstructive cardiomyopathy.

Overall incidence of congenital anomalies in infants of diabetic mothers is around 3 - 12% with an increased manifestation of congenital heart defects.

Echocardiography can be done as early as in the first trimester of pregnancy. M mode and 2D echocardiography can show cardiomegaly in around 30% of individuals. Hypertrophic obstructive cardiomyopathy occurs in 30% of infants born to mothers with diabetes mellitus.

3.11. Common cardiac lesions occurring in infants of diabetic mothers includes :-

- Hypertrophic obstructive cardiomyopathy.
- Cardiomegaly
- Intermittent or persistent bradycardia
- Persistent pulmonary hypertension
- Atrial septal defect
- Ventricular septal defect
- Patent ductus arteriosus
- Patent foramen ovale
- Tetrology of fallot
- Transposition of great vessels
- Coarctation of aorta
- Truncus arteriosus
- Hypoplastic left ventricle
- Single left ventricle

Hypertrophic obstructive cardiomyopathy normalizes by 4 - 6 months of age. Heart diseases can manifest as respiratory distress or bradycardia, tachycardia, shock, congestive cardiac failure, poor weight gain, central cyanosis and systolic murmur.

3.11.1. Hypertrophic obstructive Cardiomyopathy[16] :

It is the most common heart disease in infants of diabetic mothers. Increased left ventricular wall thickness occurs in the absence of an identifiable structural heart disease.

It can present as assymetrical septal hypertrophy. Left ventricle gets predominantly affected than right ventricle. Systolic anterior motion of mitral leaflet leading to mitral regurgitation can occur.

Dynamic left ventricular out flow tract obstruction occurs. Characterised by hyperactive precordial impulse, hyperdynamic or diminished peripheral pulses. Ejection systolic murmur in the aortic region without an ejection click can occur. Murmur occurs due to mitral regurgitation.

Echocardiogram shows left ventricular hypertrophy along with ST and T wave changes. X-ray shows normal heart to cardiomegaly. Ratio of septal to posterior ventricular wall thickness is >1.3. Symptoms resolve by 2 weeks. Septal hypertrophy normalises by 4 – 6 months. Digoxin and vasopressors are contraindicated in hypertrophic obstructive cardiomyopathy.

3.11.2. Tetrology of fallot

It is a congenital cyanotic heart disease occurring due to malalignment of aortico pulmonary septum leading to

- Right ventricular out flow tract obstruction
- Ventricular septal defect
- Over riding of aorta
- Right ventricular hypertrophy

Manifests as cyanosis, tachypnoea especially during feeding, poor weight gain, irritability, prolonged crying, heart murmur, polycythemia, clubbing of fingers. Cyanosis can be aggravated by crying or by increased physical activity. Cynotic spells or common in young infants around 2 - 4 months of old.

When it occurs in association with atrial septal defect it is called as pentalogy of fallot. Surgical correction is mandatory. Ventricular septal defect closure is done with a patch along with opening the right ventricular out flow tract by removing the thickened muscle that leads to obstruction. Surgery should be performed as early as possible for better prognosis.

3.11.3. Transposition of great vessels [18]

The overall incidence is 5 – 7% but the proportion increases in infants of diabetic mothers. Diabetes mellitus in pregnant women is risk factor for the foetus to develop transposition of great vessels. They may have coarctation of aorta in association. Atrio ventricular concordance with discordance of great vessels occurs. It is a congenital Cyanotic heart disease.

Right ventricle pumps blood directly in to the aorta bypassing the lungs whereas left ventricle pumps oxygenated blood back in to the lungs through the pulmonary artery. Two separate circulatory systems exist. For new borns with established diagnosis prostaglandin infusion should be administered to maintain the patency of ductus arteriosus which allows mixing of systemic and pulmonary circuits.

Symptoms appear at birth or early in life. Presents with cyanosis breathlessness, poor feeding, clubbing, respiratory distress. Can be diagnosed antenatally through fetal echocardiogram in the earlier weeks of gestation.

Surgery can be performed as early as possible like Mustard and Senning atrial switch repair, Jantene arterial switch repair with good postoperative outcome.

3.11.4. Ventricular Septal Defect [19]

Occurs commonly in infants of diabetic mothers. May involve any portion of the septum but the commonest site is membranous part of the septum. Left to right shunt occurs which is determined by the level of pulmonary vascular and systemic vascular resistance. When communication present is <5mm it is restrictive type of VSD.

Clinical findings depend upon size of the defect, pressure difference, pulmonary blood flow. VSD with minimal left to right shunt and normal pulmonary artery pressure occurs commonly. They remain asymptomatic, their lesion is diagnosed during routine physical examination. In preterm babies the VSD murmur is heard earlier because of the rapid decrease in pulmonary vascular resistance.

Clinical findings include a prominent left precordium, a PSM along the lower left sternal border, a systolic thrill. VSD with pulmonary hypertension leads to breathlessness, poor growth, feeding difficulties, respiratory tract infections, congestive cardiac failure, reversal of shunt, death in earlier stages of life.

X-ray may show cardiomegaly, borderline increase in pulmonary vasculature. ECG shows Left ventricular hypertrophy. Right ventricular

hypertrophy indicates pulmonary hypertension. Echo shows the size, position of VSD.

Spontaneous closure occurs in 30 - 50% of small defects in the 1st 2 years of life. 80% of muscular VSD undergoes spontaneous closure. Surgical closure is indicated in large VSD with Pulmonary hypertension, symptoms not improved by medication.

3.11.5. Patent Ductus Arteriosus [20]

Occurs in 10% of babies with CHD; its proportion increases in IDM. Functional closure of ductus arteriosus occurs soon after birth. But if the patency of the ductus is maintained it leads to shunting of blood across the left to right shunt in to the pulmonary artery.

PDA in term babies occurs due to deficiency of muscularis media where as in preterm babies they are structurally normal. PDA existing beyond 1st week of life in term babies is unlikely to close.

Small PDA is commonly asymptomatic. Growth retardation, CCF occurs in large PDA. Bounding peripheral pulses, wide pulse pressure, mild cardiomegaly, and continuous murmur occurs in the left 2nd ICS. In small PDA ECG is normal. In larger ones it shows LVH or biventricular hypertrophy. X-ray shows increased pulmonary vascular markings. Echo shows increased left atrial, left ventricular dimensions in larger shunts.

Doppler shows the abnormal flow in the aorta and in the pulmonary artery. Medical closure can be done by drugs like brufen and indomethacin. Small PDA can be closed with intravascular coils. Surgical closure is indicated as early as possible.

3.11.6. Atrial Septal Defect [21]

The incidence of ostium secundum type is 7% of all congenital heart diseases. It incidence is higher in infants of diabetic mothers.

Types

- Ostium primum type
- Ostium Seccundum type
- Sinus Venosus variant

Ostium seccundum type is the commonest type of ASD occurring in the region of fossa ovalis. Symptomatic children has OS opening >2cm. Left to right shunt depends on size of the defect, vascular resistance of systemic and pulmonary arteries.

With the fall in pulmonary vascular resistance the shunt across ASD increases. Most often asymptomatic. Diagnosed during physical examination. FTT can occur. Rarely produces CCF. Mild left precordial bulge is present. Wide fixed splitting of second heart sound is heard. Ejection systolic murmur may be heard. X-ray shows enlargement of

right atrium and right ventricle. Cardiomegaly may be present. ECG shows right axis deviation with right bundle branch block. Surgical closure is indicated for symptomatic patients. Timing of elective surgery is after 1 year of age but before school entry.

3.11.7. Patent Foramen Ovale

It is an ECG finding during infancy usually not haemodynamically significant. It is not considered as an ASD. PFO plays an important role if another structural defect like pulmonary stenosis, atresia exists. Tricuspid valve anomalies leads to right to left shunt across the PFO leading to cyanosis. In new born period left to right shunt occurs across PFO. PFO may be patent in upto 15 - 30% of adults leading to thromboembolic complications. Device closure of the defect is essential in persons prone to thromboembolic complications.

3.11.8. Truncus arteriosus [22]

It is a conotruncal malformation. Single arterial trunk arises from the heart. It supplies systemic, pulmonary and coronary arteries. Ventricular Septal defect occurs commonly. Truncus arteriosus manifests with cyanosis, growth retardation, hyperdynamic precordium. It is a complex congenital cyanotic heart disease occurring in infants of diabetic mothers.

3.11.9. Coarctation of aorta [23]

Common site is just below the origin of left subclavian artery. It is commonly associated with bicuspid aortic valve. Sub aortic stenosis is a potential associated lesion. Differential cyanosis commonly occurs. Blood pressure is raised in the vessels which arise proximal to Coarctation of aorta. Blood pressure in lower limbs is much lower than in upper limbs. Claudication pain occurs. Radiofemoral delay occurs. Collatral circulation gets established. It leads to notching in the inferior border of ribs. In cases with severe coarctation ductus closure leads to hypoperfusion. Prostaglandin infusion maintains the patency of ductus arteriosus. Surgery is the treatment of choice. Area of stenosis is resected and reanastamosis is done.

3.11.10. Persistent Pulmonary Hypertension [24]

It occurs due to disruption in transition from normal fetal to neonatal circulation. Persistent elevation in pulmonary vascular resistance occurs. Normally fall in pulmonary vascular resistance occurs after birth. Maternal diabetes mellitus is an important risk factor for the development of persistent pulmonary hypertension. It should be differentiated from other congenital heart diseases and parenchymal lung disorders. Cyanosis may occur with prominent precordial impulse, loud second heart sound, systolic murmur due to tricuspid regurgitation.

Pulmonary blood flow is normal or diminished. ECG shows RV predominance. Echo shows haemodynamic shunting, tricuspid regurgitation suggesting pulmonary hypertension. Supplemental oxygen with inhaled nitric oxide remains the treatment of choice.

3.12. Causes of Respiratory distress in infants of diabetes mothers

- Transient tachypnoea of new born
- Respiratory distress syndrome
- Persistent pulmonary hypertension
- Polycythemia
- Hypertrophic obstructive cardiomyopathy
- Acyanotic heart diseases
- Cyanotic heart diseases
- Congenital Pneumonia
- Pneumothorax
- Diaphrgmatic hernia
- Other congenital malformations of the lungs.

In infants of diabetic mothers with respiratory distress the ratio of right ventricular pre ejection period to ventricular time is raised. There is an abnormality in the transitional pulmonary circulation. Closure of Patent ductus arteriosus is delayed in infants of diabetes mothers.

Fall in pulmonary artery pressure takes time to develop hence they are prone to develop persistent pulmonary hypertension.

Similar study had been done by Abu Sulaiman et al, Subiah et al, at King Khalidh University Hospital at Riyadh [25]. Their study involved hundred infants of diabetic mothers born in their hospital over the study period. Their objective was to study the spectrum of cardiac disorders manifested by them.

Diabetes mellitus is a risk factor for the development of congenital heart diseases. Careful evaluation and early diagnosis of congenital heart diseases in the high risk group is highly indicated.

They manifested a variety of cardiac disorders like PDA, HOCM, VSD, ASD, PS, TOF, TGV. The article has been published in journal of pediatric cardiology April 2004, Volume 25 issue 2, PP 137 - 140.

Similar study was made by H Narchi et al and N Kilayat et al [26] regarding the echocardiographic findings in the infants of diabetic mothers. The study was conducted in United Kingdom. The article was published in the Journal of Pediatric Cardiology, Volume 2 April to June 2000.

Thomas et al, Roisland et al [27], John P Hubbel et al, Alexander Nadas et al had done a similar study regarding the cardiac manifestations of diabetic mothers.

Review of 470 infants of diabetic mothers at Joslin Clinic Boston showed 4% incidence of congenital heart diseases which had 5 times greater incidence than the general population.

No relationship between gestational factors, heart disease was found in the study. No single specific clue exists but persistent distress, cyanosis, murmur, ECG changes, Cardiomegaly should make us think of any congenital heart diseases.

4. METHODOLOGY

4.1. Title of the Study

The spectrum of cardiac disorders in infants of diabetic mothers.

4.2. Aim of the Study

- The objective of the study is to identify neonates born to gestational diabetes mellitus, type – 1 and type – 2 mellitus and to detect the spectrum of congenital heart diseases manifested by them.

4.3. Type of Study

Prospective observational study

4.4. Study period

Between January 2014 to June 2014 a prospective study of 50 consecutive infants of diabetic mothers admitted at Tirunelveli Medical College Hospital was under taken.

4.5. Study Population

All infants of diabetic mothers admitted in neonatal intensive care unit in Tirunelveli Medical College Hospital were included in the study.

4.6. Sample Size

50 consecutive infants of diabetic mothers admitted in neonatal intensive care unit in Tirunelveli Medical College Hospital.

4.7. Inclusion Criteria

All live born infants of mothers with gestational diabetes mellitus, type 1 insulin dependent diabetes mellitus, type 2 non insulin dependent diabetes mellitus.

4.8. Exclusion Criteria

- Infants of diabetic mothers with severe hypoxic ischemic encephalopathy.
- Mothers with TORCH infections.
- Mothers with systemic lupus erythematosus
- Mothers on teratogenic cardiotoxic drugs
- Babies with other syndromic anomalies.

4.9. Method of Study

- Infants of diabetic mellitus will be evaluated in the first 10 days of life by detailed clinical examination with special reference to cardiovascular system.
- Chest X-ray
- Electrocardiogram

- Echocardiography

All the above mentioned investigations will be done after obtaining informed consent from the mothers.

4.10. Results of the Study

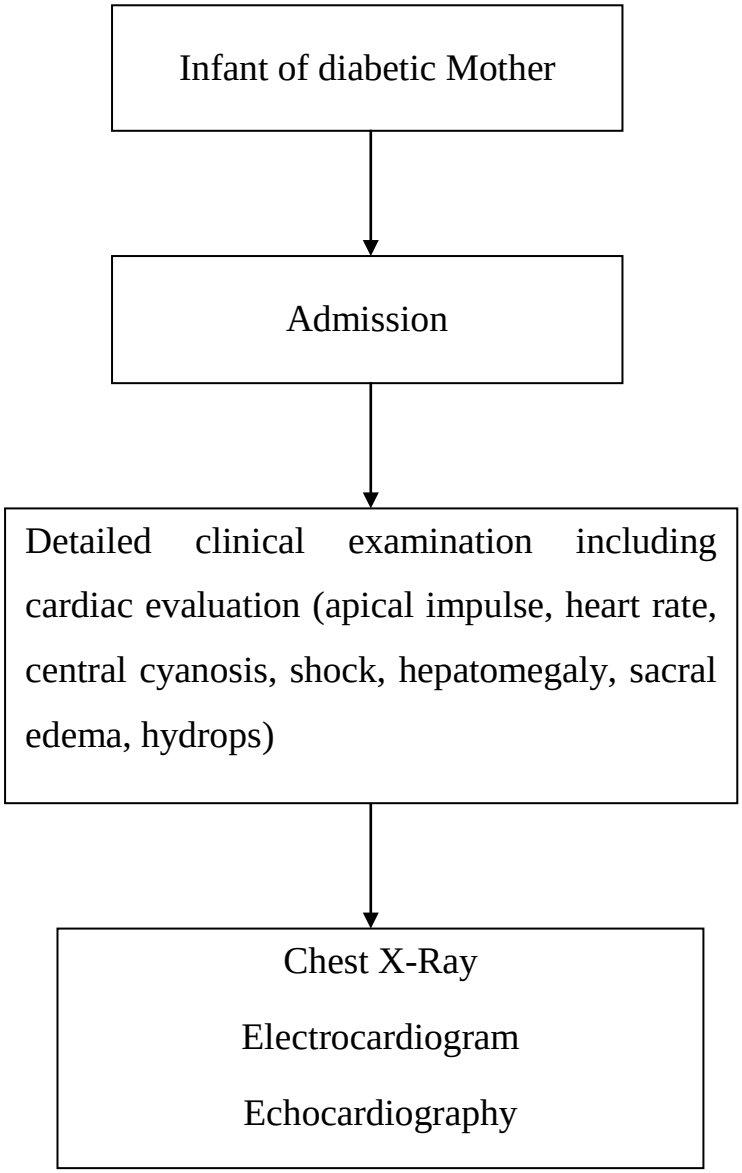
Data will be analysed under the following basis.

- Presence or absence of cardiac disorder in infants of diabetic mothers.
- Type of cardiac disorder.
- Severity of cardiac disorder in the form of shock, congestive cardiac failure.
- Association between birth weight and occurrence of cardiac disorder.
- Association between clinical manifestations and echocardiographic findings.
- Association between X-ray findings and echocardiographic findings.
- Association between ECG findings and echocardiographic findings.

- Association between the occurrence of congenital heart disease in treated and untreated mothers.

- Association between the occurrence of congenital heart disease in term and preterm babies of infants of diabetic mothers.

Methodology



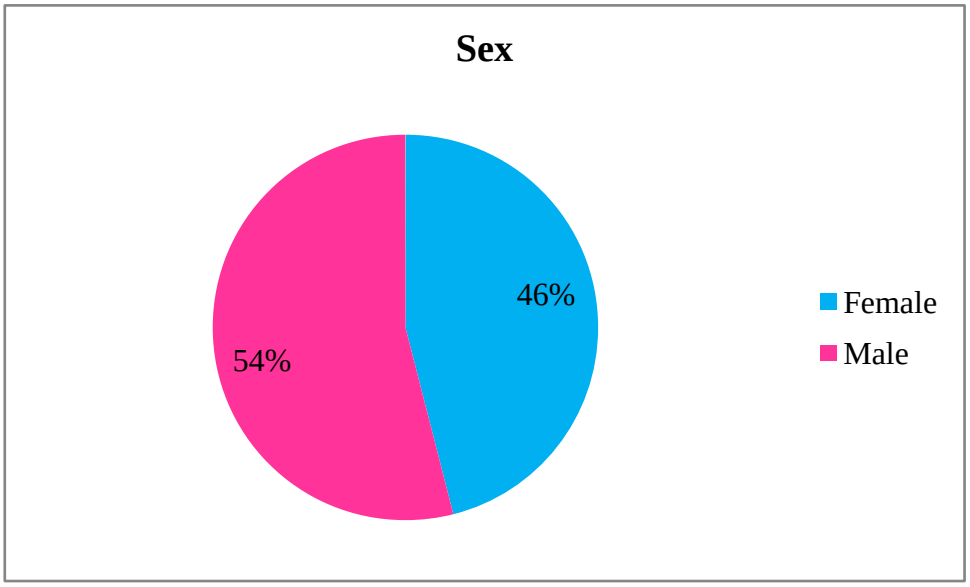
5. OBSERVATION

5.1. Sex :

Out of the 50 cases studied 27 were male and 23 were female

Table : 1

Sex	Frequency	Percentage
Female	23	46%
Male	27	54%



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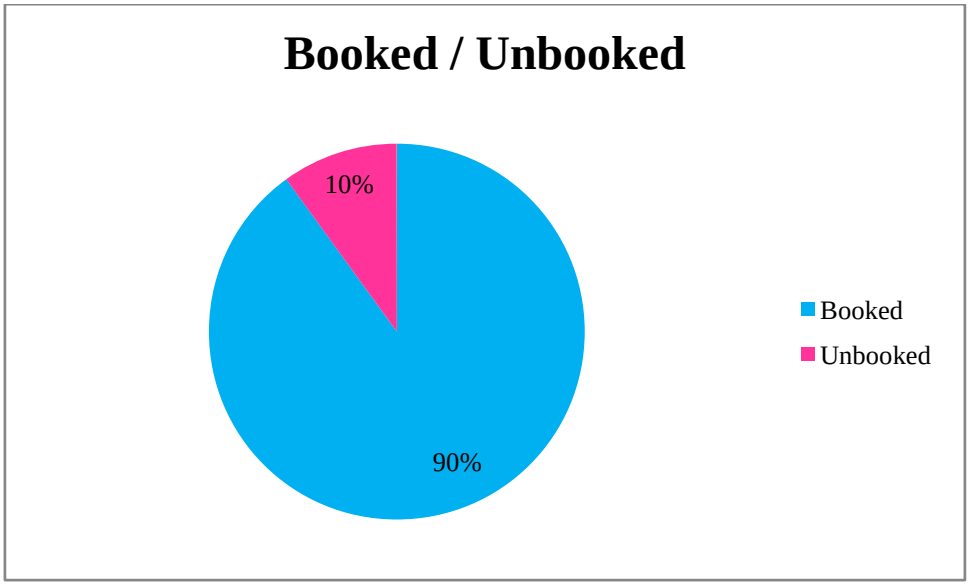
5.2. Booked / Unbooked :

Among the 50 cases studied 45 cases were booked and 5 cases were unbooked.

Table : 2

Booked / Unbooked	Frequency	Percentage
Booked	45	90%
Unbooked	5	10%

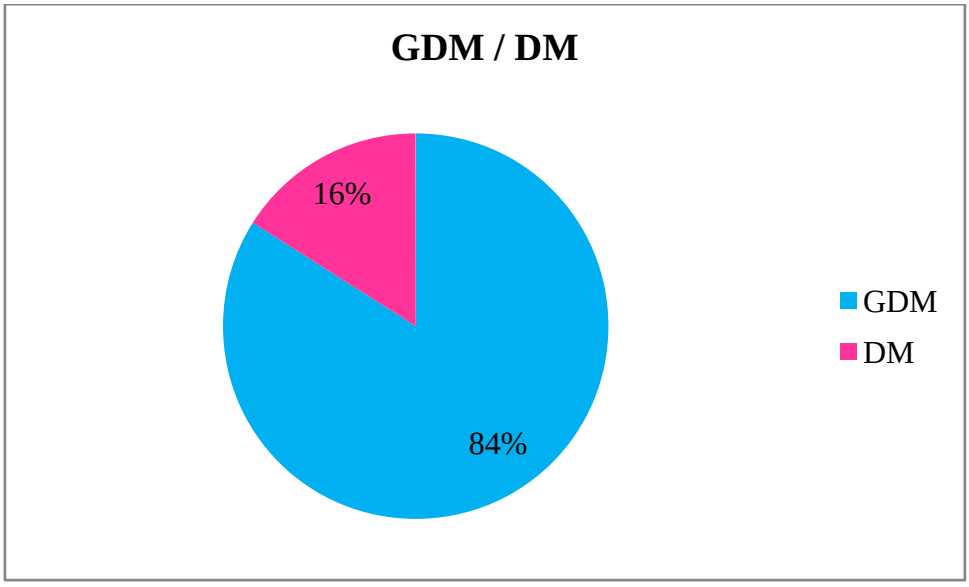


5.3. GDM / DM :

Among the 50 mothers studied 42 had GDM and 8 had pregenstational diabetes mellitus.

Table : 3

GDM / DM	Frequency	Percentage
GDM	42	84%
DM	8	16%

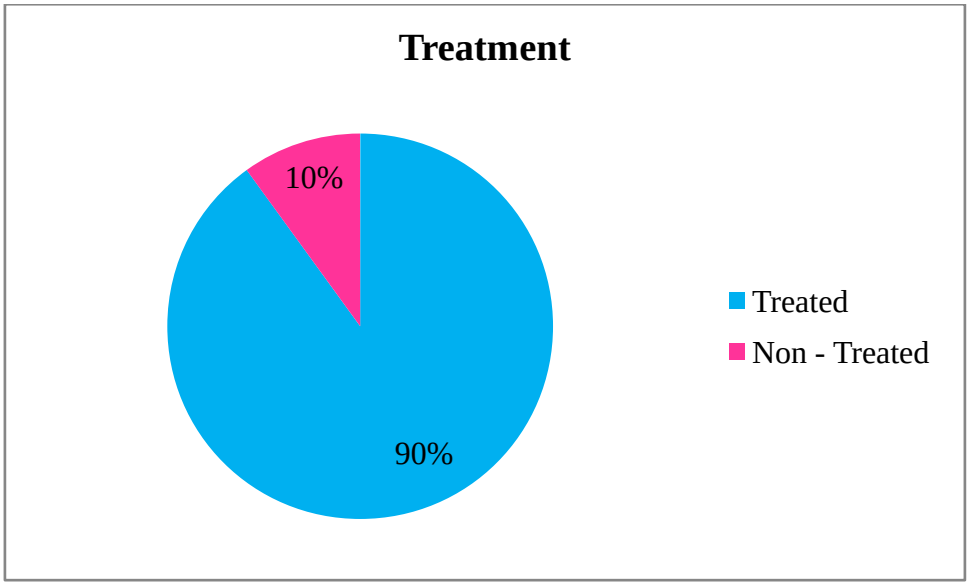


5.4. Treatment Details :

Among the 50 mothers 45 were treated and 5 were untreated

Table : 4

Treatment	Frequency	Percentage
Treated	45	90%
Non - Treated	5	10%

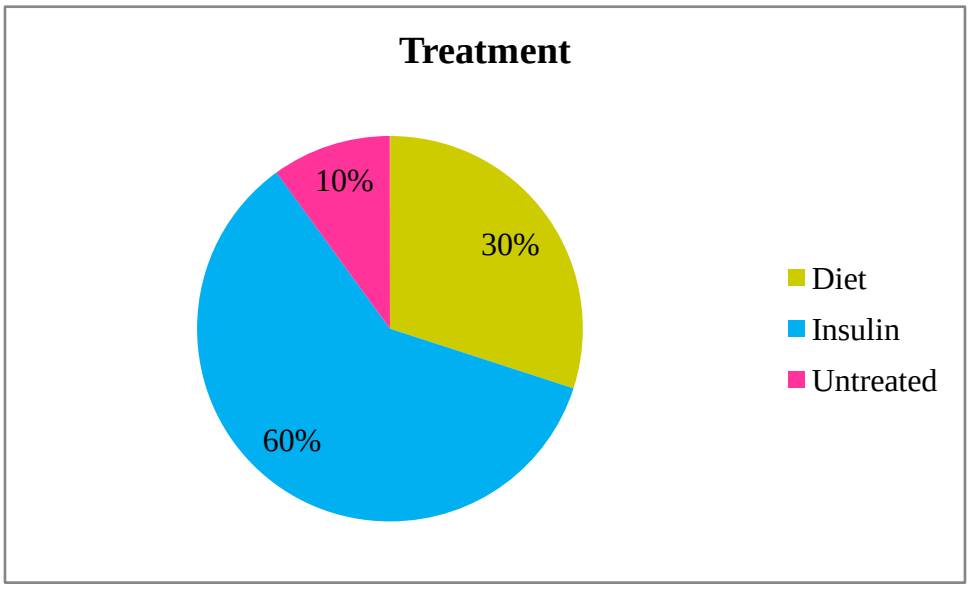


5.5. Treatment Details :

Out of the 50 mothers 30 were treated with insulin and 15 mothers were on meal plan and 5 mothers were untreated.

Table : 5

Treatment	Frequency	Percentage
Diet	15	30%
Insulin	30	60%
Untreated	5	10%

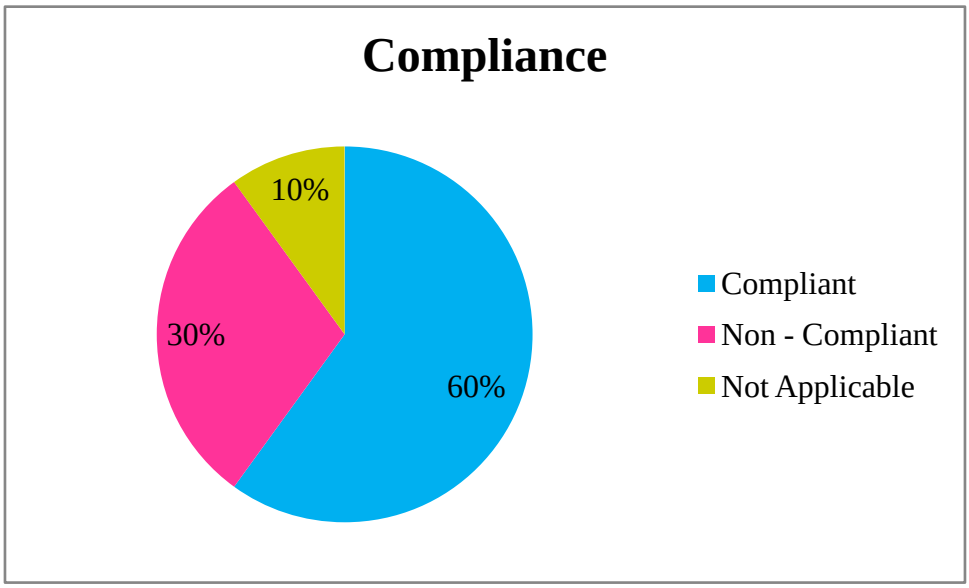


5.6. Compliance :

Among the 50 mothers treated 30 were compliant and 15 were non compliant and 5 were untreated.

Table : 6

Treatment	Frequency	Percentage
Compliant	30	60%
Non - Compliant	15	30%
Not Applicable	5	10%

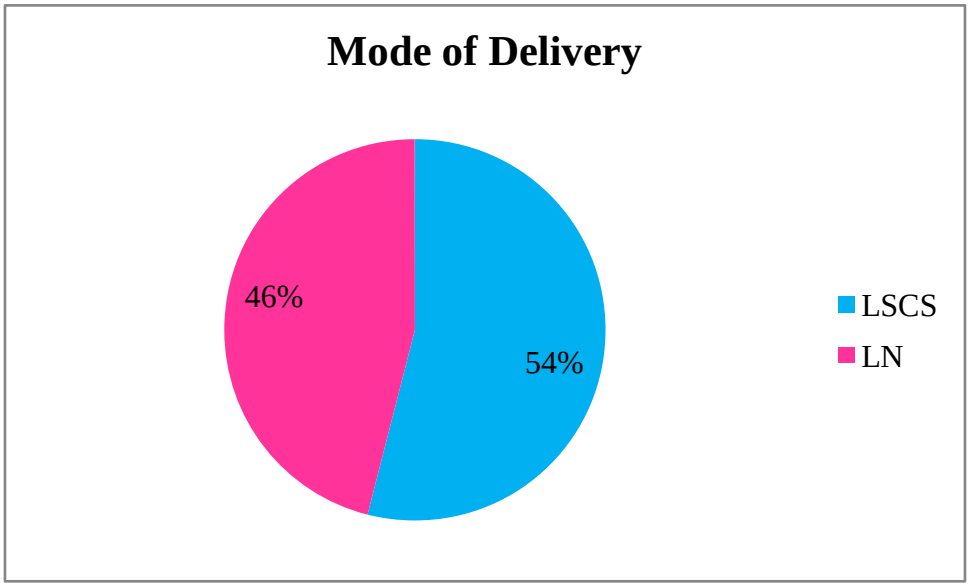


5.7. Mode of Delivery :

Among 50 mothers 27 had cesarean section and 23 had normal labour.

Table : 7

Mode of Delivery	Frequency	Percentage
LSCS	27	54%
LN	23	46%

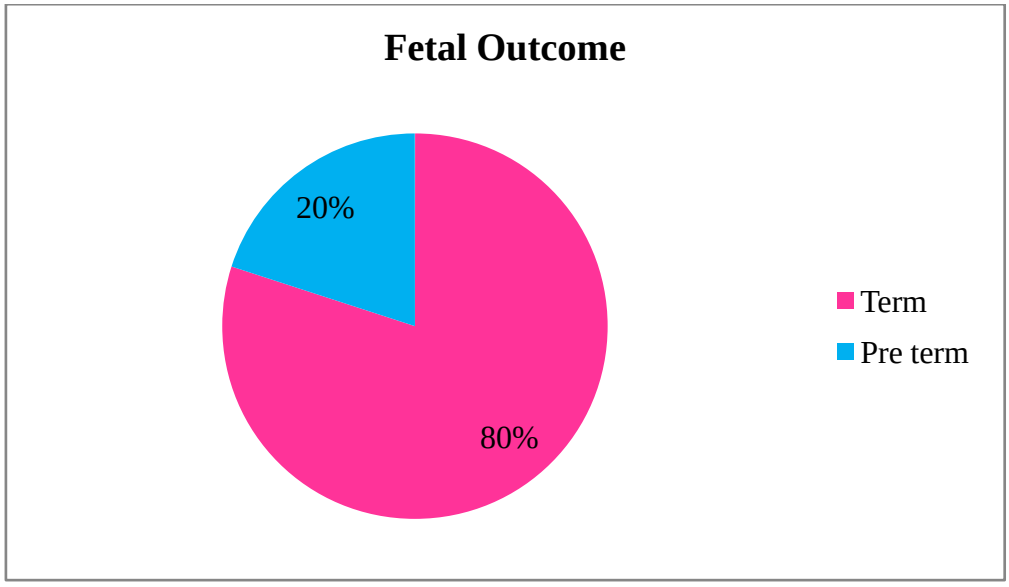


5.8. Fetal Out come :

Among the 50 babies studied 40 were term babies and 10 were preterm babies.

Table : 8

Fetal Out come	Frequency	Percentage
Term	40	80%
Preterm	10	20%

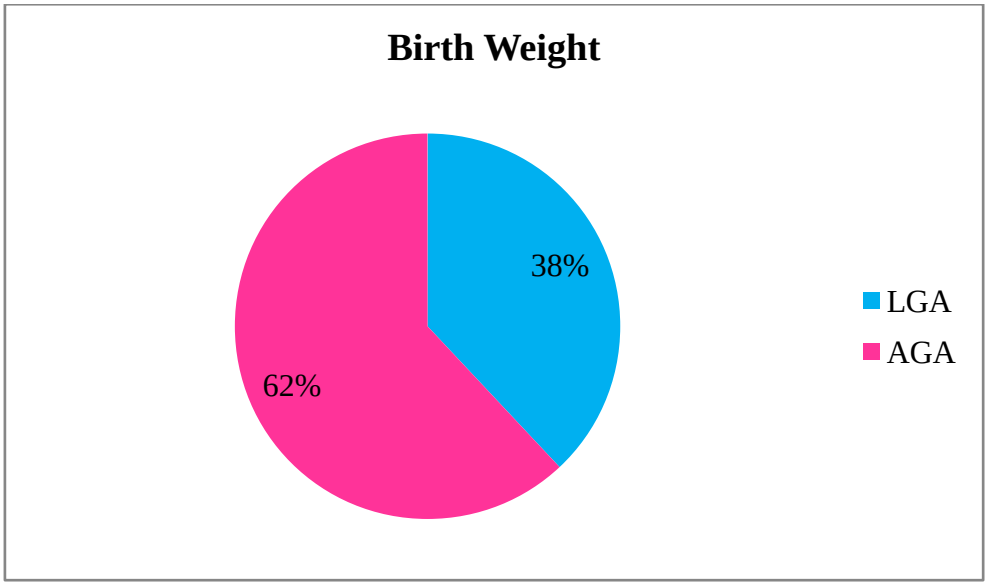


5.9. Birth Weight :

Among the 50 babies studied 19 were large for gestational age and 31 were average for gestational age.

Table : 9

Birth Weight	Frequency	Percentage
LGA	19	38%
AGA	31	62%

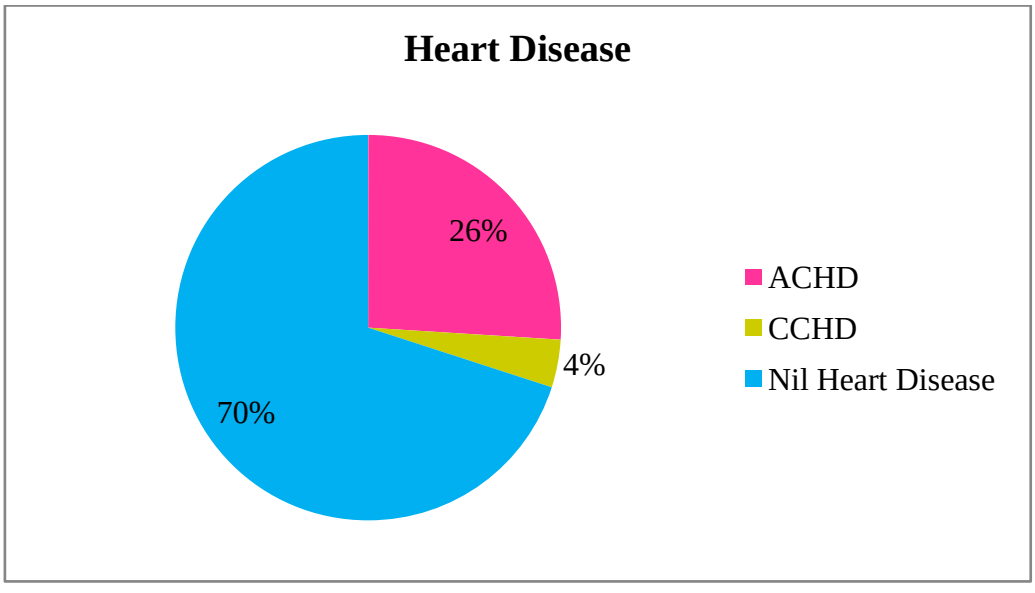


5.10. Congenital Heart Disease

Among the 50 babies studied 15 had congenital heart disease of which 13 had Acyanotic heart disease and 2 had Cyanotic heart disease.

Table : 10

Congenital Heart Disease	Frequency	Percentage
ACHD	13	26%
CCHD	2	4%
Nil Heart Disease	35	70%

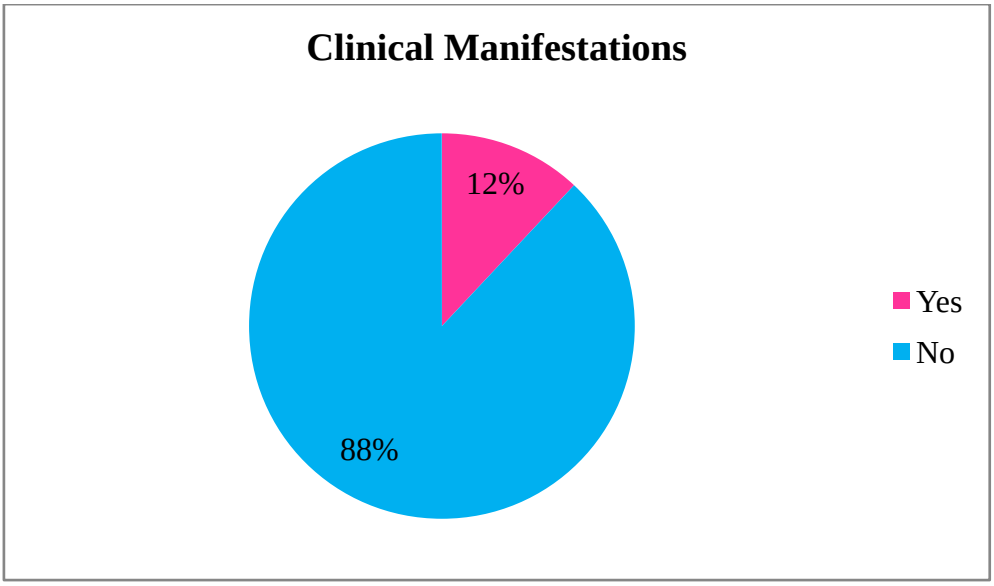


5.11. Clinical Manifestations :

Out of the 50 babies studied 6 had clinical manifestations.

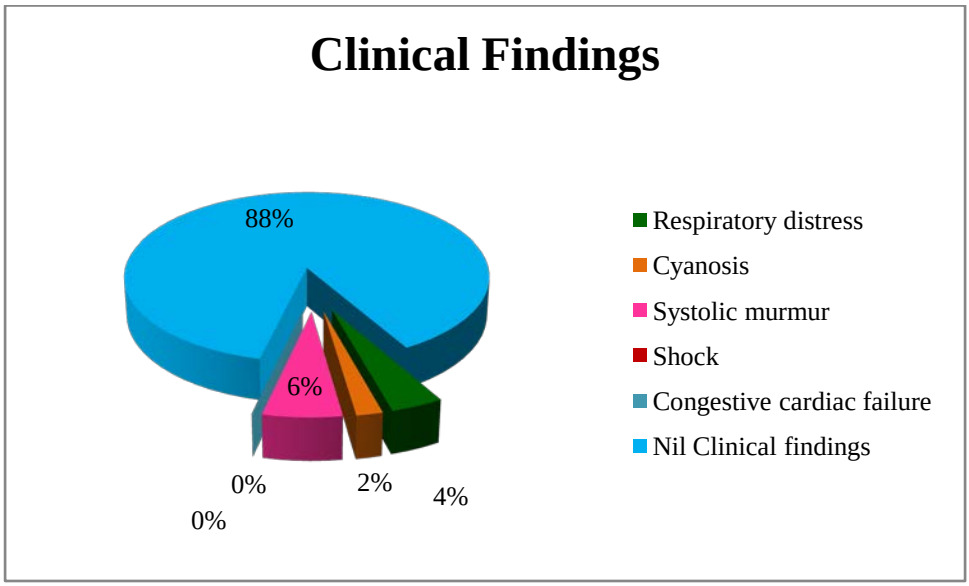
Table : 11

Clinical Manifestation	Frequency	Percentage
Yes	6	12%
No	44	88%



5.11.1. Spectrum of Clinical Findings

Clinical Findings	Frequency	Percentage
Respiratory distress	2	4%
Cyanosis	1	2%
Systolic murmur	3	6%
Shock	Nil	0%
Congestive cardiac failure	Nil	0%
Nil Clinical findings	44	88%

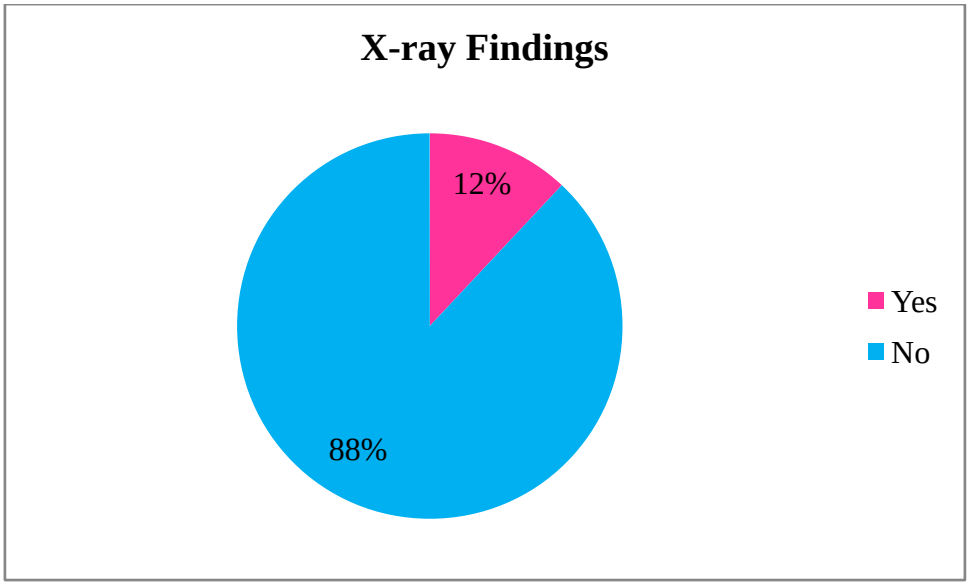


5. 12. X-Ray findings :

Out of the 50 babies studied 6 had X-Ray findings.

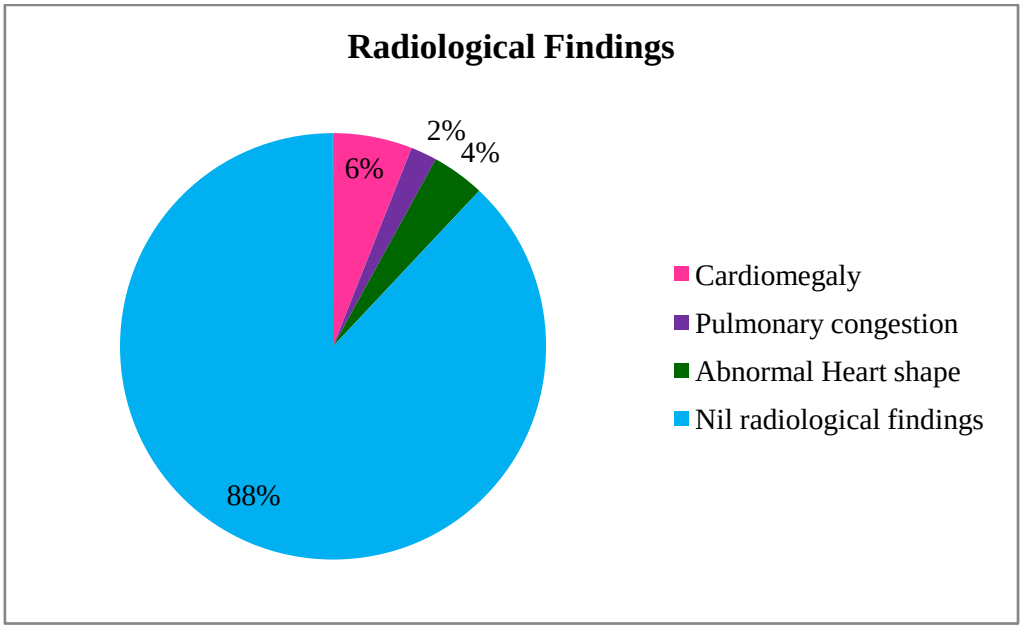
Table : 12

X - Ray findings	Frequency	Percentage
Yes	6	12%
No	44	88%



5.12.1. Spectrum of radiological findings :

Findings	Frequency	Percentage
Cardiomegaly	3	6%
Pulmonary congestion	1	2%
Abnormal Heart shape	2	4%
Nil radiological findings	44	88%

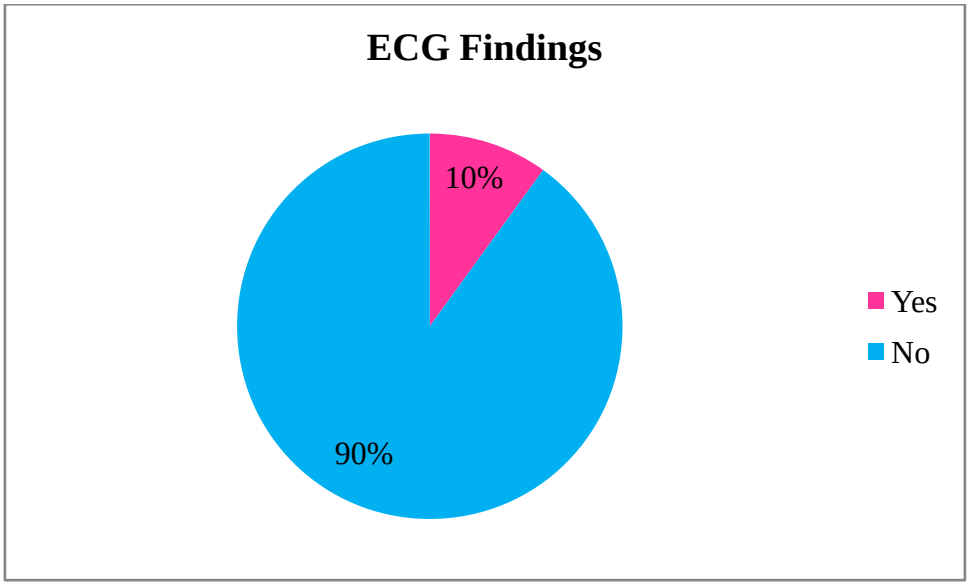


5.13. Electrocardiogram :

Out of the 50 babies studied 5 had ECG changes.

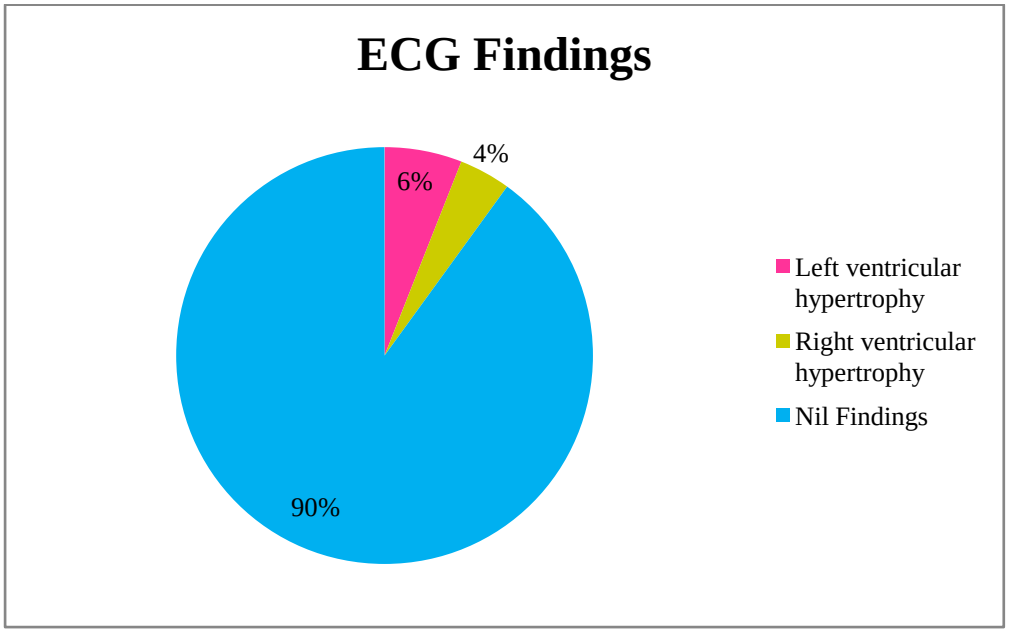
Table : 13

Electrocardiogram	Frequency	Percentage
Yes	5	10%
No	45	90%



5.13.1. Spectrum of ECG findings :

Findings	Frequency	Percentage
Left ventricular hypertrophy	3	6%
Right ventricular hypertrophy	2	4%
Nil Findings	45	90%

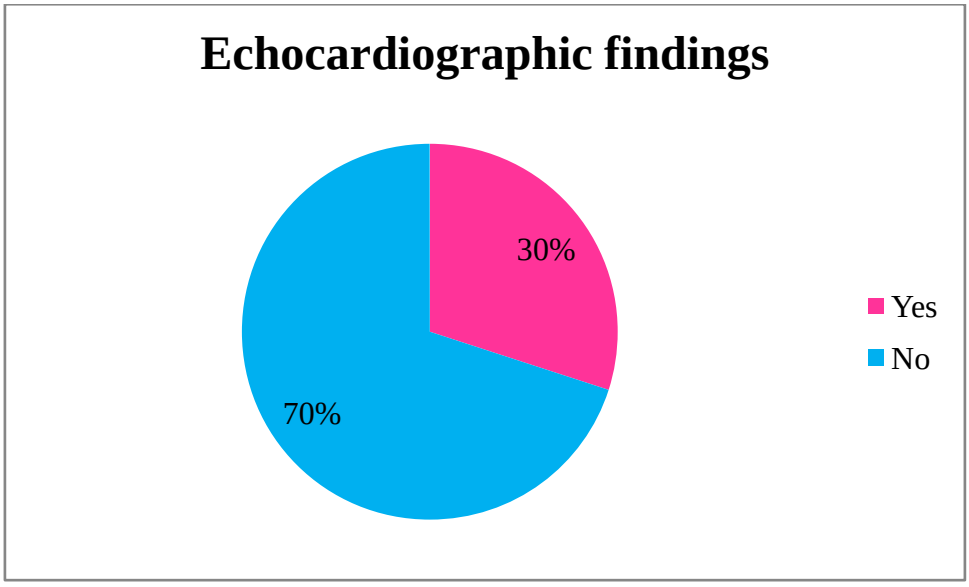


5.14. Echocardiogram :

Out of the 50 babies studied 15 had Echocardiogram findings

Table : 14

Echocardiogram	Frequency	Percentage
Yes	15	30%
No	35	70%



6. RESULTS

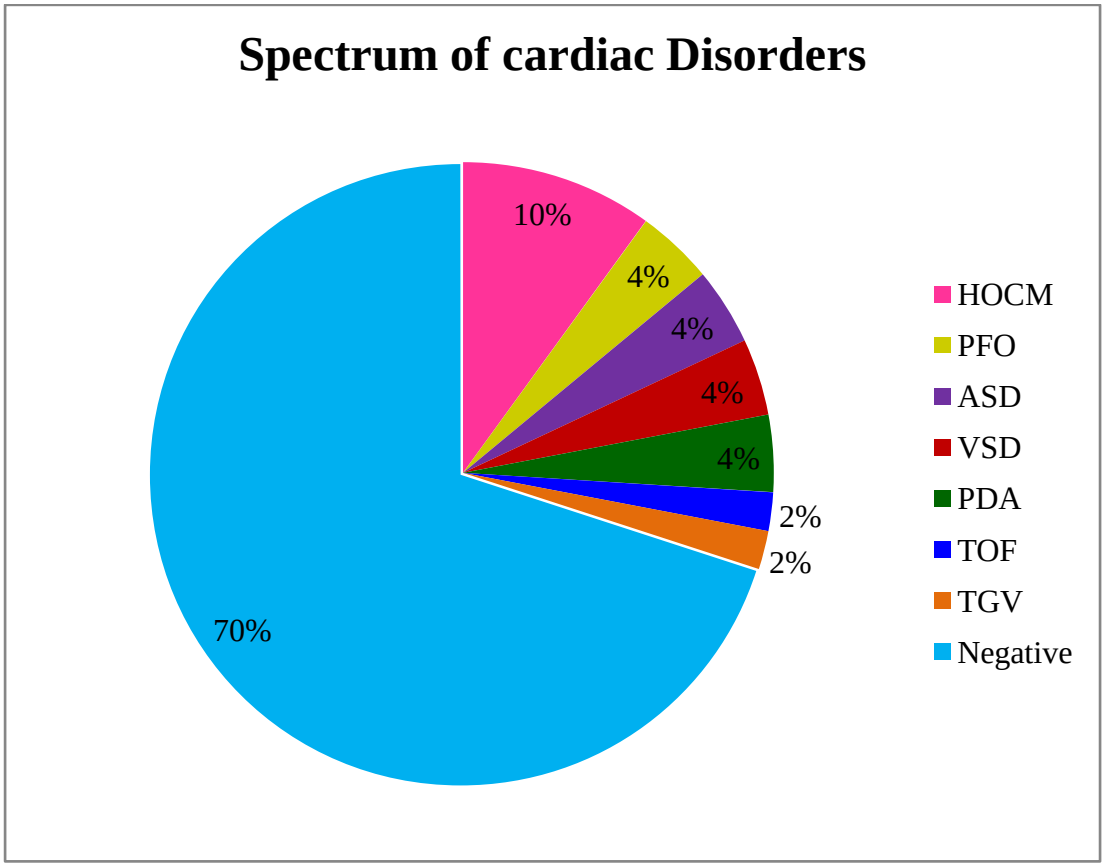
6.1. Spectrum of cardiac Disorders :

Among the 50 IDM who underwent echocardiography 15 of them were found to have the following cardiac diseases depicted below.

Table - 15

Heart Disease	Frequency	Percentage
HOCM	5	10%
PFO	2	4%
ASD	2	4%
VSD	2	4%
PDA	2	4%
TOF	1	2%
TGV	1	2%
Negative	35	70%

6.1.1. Spectrum of cardiac Disorders



- 10% of IDM were found to have hypertrophic obstructive cardiomyopathy.
- 4% of IDM were found to have Patent Foramen Ovale
- 4% of IDM were found to have Atrial Septal Defect
- 4% of IDM were found to have Ventricular Septal Disease.
- 4% of IDM were found to have Patent Ductus Arteriosus.
- 2% of IDM were found to have transposition of great vessels.
- 2% of IDM were found to have tetrology of fallot.

6.1.2. Clinical, Radiological, Electrocardiographic, Echocardiographic findings in infants of diabetic mothers

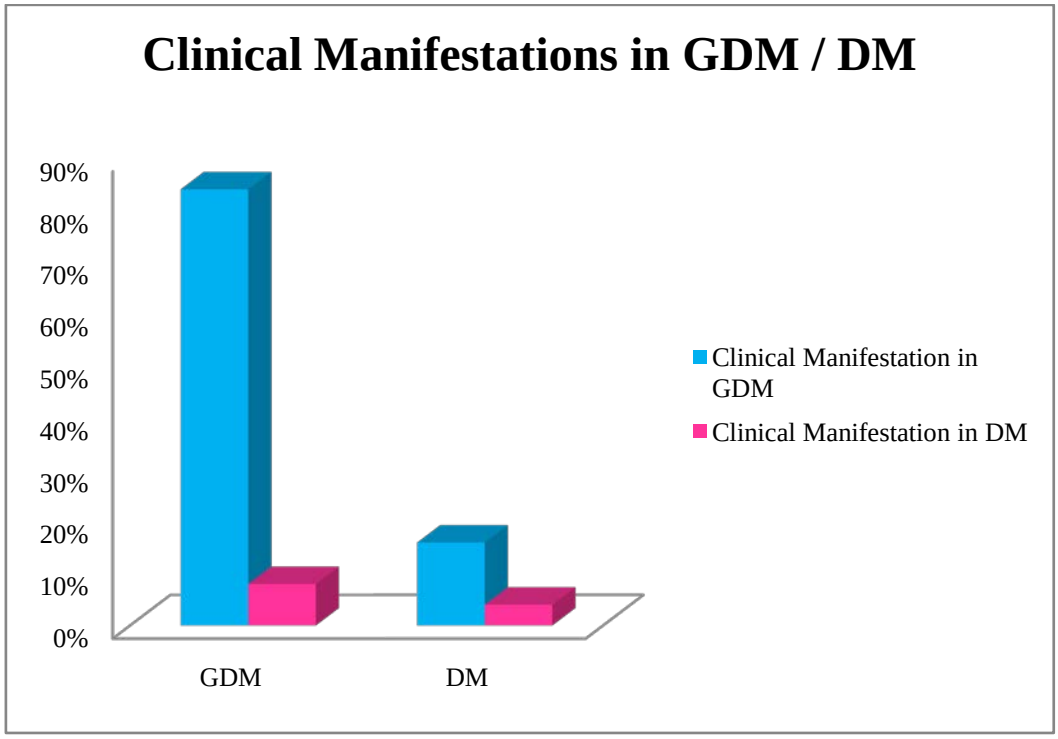
Sl. No	GDM/IDM	Clinical	X-Ray	ECG	Echo
1.	GDM	–	–	–	HOCM
2.	DM	–	+	–	HOCM
3.	DM	+	+	+	VSD
4.	GDM	–	+	–	HOCM
5.	GDM	+	_	–	TOF
6.	GDM	+	_	–	PDA
7.	GDM	_	_	–	PFO
8.	GDM	_	_	–	PFO
9.	DM	_	+	–	HOCM
10.	GDM	_	_	+	ASD
11.	GDM	+	_	_	TGV
12.	GDM	_	_	+	ASD
13.	GDM	+	_	_	PDA
14.	GDM	_	+	+	HOCM
15.	DM	+	+	+	VSD

6.2. Clinical Manifestations in GDM / DM

	Frequency	Percentage
GDM	42	84%
DM	8	16%
Clinical Manifestation in GDM	4	8%
Clinical Manifestation in DM	2	4%

- In this study among 50 babies, 42 (84%) of babies were born to gestational diabetes mellitus mothers, 8(16%) babies were born to mothers with pre gestational diabetes mellitus.

- Among them 4(8%) of babies born to GDM mothers had clinical manifestations and 2 (4%) of babies born to pre gestational diabetes mellitus had clinical manifestations.



INTERPRETATION

- ❖ Correlation is significant at point 0.01 level (2-tailed)
- ❖ 2-tailed significance - 0.208.

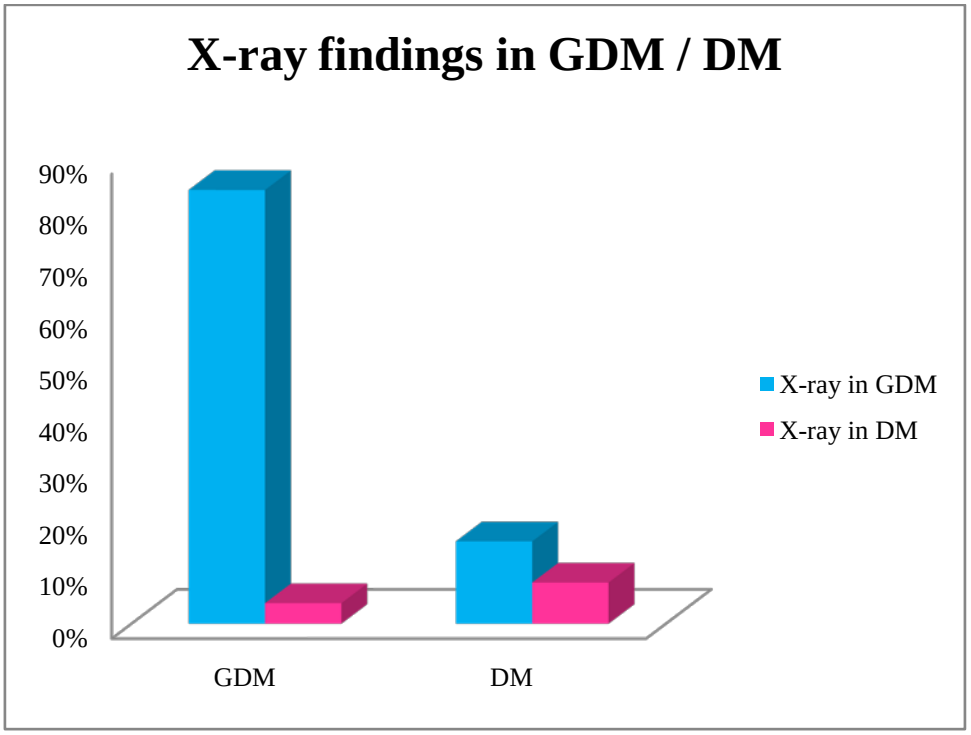
There exists no relationship between the clinical manifestations exhibited and the presence of GDM / pre gestational diabetes mellitus in the mother.

6.3. X-ray findings in GDM / DM

	Frequency	Percentage
GDM	42	84%
DM	8	16%
X-ray in GDM	2	4%
X-ray in DM	4	8%

- In this study among 50 babies, 42 (84%) of babies were born to gestational diabetes mellitus mothers, 8(16%) babies were born to mothers with pre gestational diabetes mellitus.

- Among them 2(4%) of babies born to GDM mothers had radiological findings and 4 (8%) of babies born to pre gestational diabetes mellitus had radiological findings.



INTERPRETATION

- ❖ Correlation is significant at point 0.01 level (2-tailed)
- ❖ 2-tailed significance - 0.208.

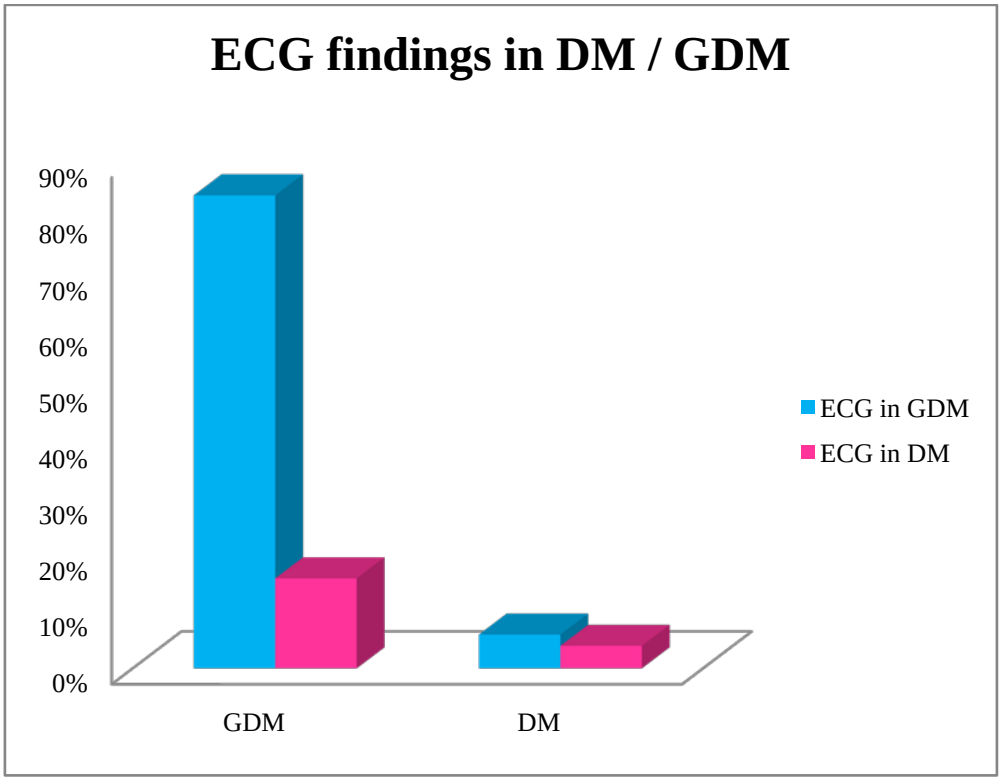
There exists no relationship between the radiological findings exhibited and the presence of GDM / pre gestational diabetes mellitus in the mother.

6.4. ECG findings in DM / GDM

	Frequency	Percentage
GDM	42	84%
DM	8	16%
ECG in GDM	3	6%
ECG in DM	2	4%

- In this study among 50 babies, 42 (84%) of babies were born to gestational diabetes mellitus mothers, 8(16%) babies were born to mothers with pre gestational diabetes mellitus.

- Among them 3(6%) of babies born to GDM mothers had ECG findings and 2 (4%) of babies born to pre gestational diabetes mellitus had ECG findings.



INTERPRETATION

- ❖ Correlation is significant at point 0.01 level (2-tailed)
- ❖ 2-tailed significance - 0.301.

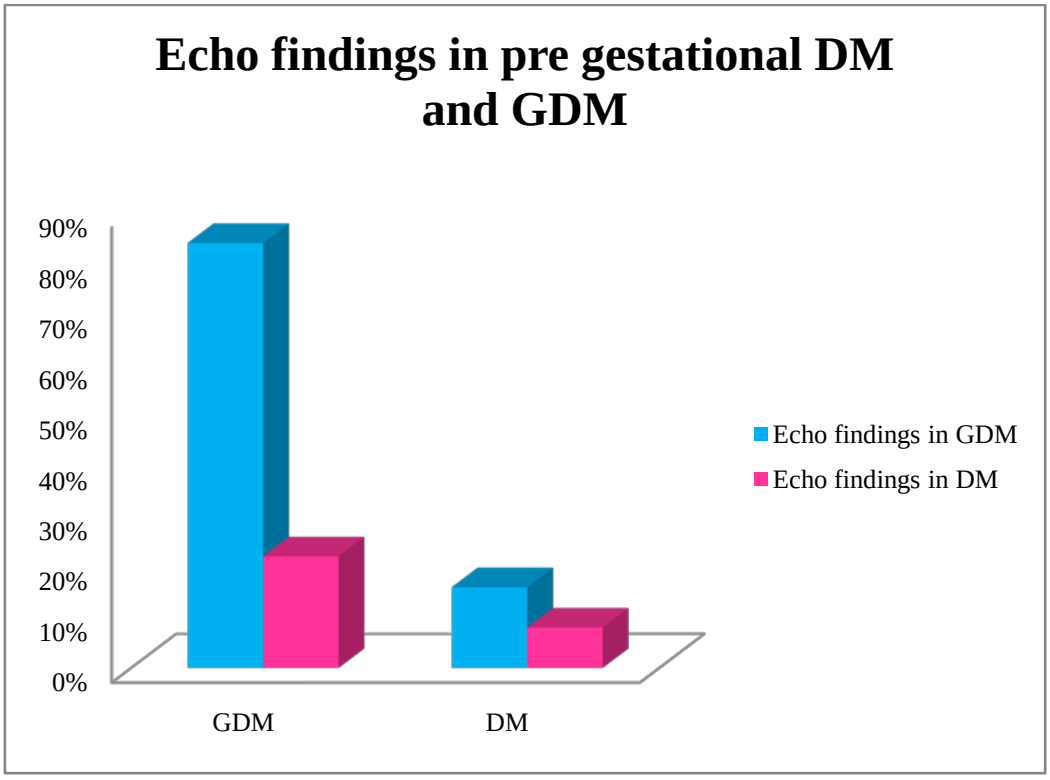
There exists no relationship between the electrocardiographic exhibited and the presence of GDM / pre gestational diabetes mellitus in the mother.

6.5. Echo findings in pre gestational DM and GDM

	Frequency	Percentage
GDM	42	84%
DM	8	16%
Echo findings in GDM	11	22%
Echo findings in DM	4	8%

- In this study among the 50 babies who were infants of diabetic mothers 42 babies (84%) were born to mothers with gestational diabetes mellitus. 8 babies (16%) were born to mothers with pre gestational diabetes mellitus.

- Among them 11 (22%) babies of gestational diabetes mellitus had Echo findings and 4 (8%) of babies of pre gestational diabetes mellitus had Echo findings.



INTERPRETATION

- ❖ Correlation is significant at point 0.01 level (2-tailed)
- ❖ 2-tailed significance - 0.743.

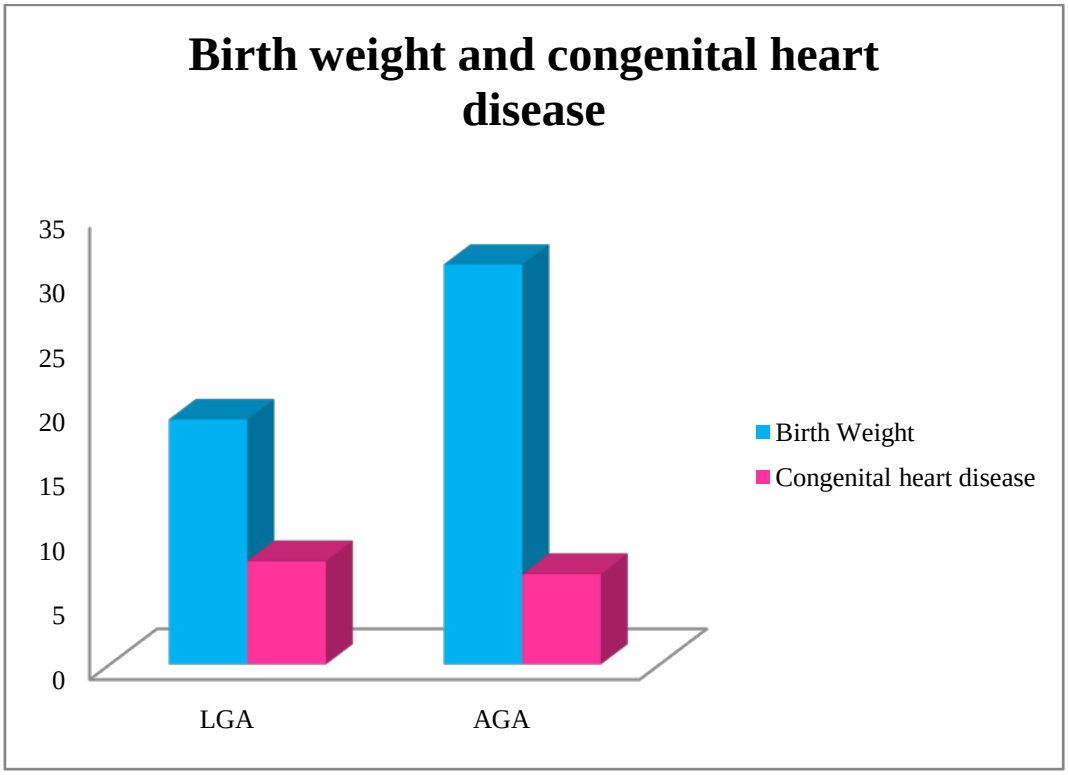
There exists no relationship between the echocardiographic findings exhibited and the presence of GDM / pre gestational diabetes mellitus in the mother.

6.6. Birth weight and congenital heart disease

Birth Weight		Congenital heart disease	
LGA	**AGA**	**LGA**	**AGA**
19	31	8	7

- Among the 50 babies in this study 19 (38%) were large for gestational age and 31 (62%) were average for gestational age from the percentile charts.

- Congenital heart diseases occurred in 8 babies (16%) of large for gestational age babies and 7 (14%) of average for gestational age babies.



- ❖ Correlation is significant at point 0.01 level (2-tailed)
- ❖ Correlation is significant at the 0.05 level (2- tailed).
- ❖ 2-tailed significance - 0.421

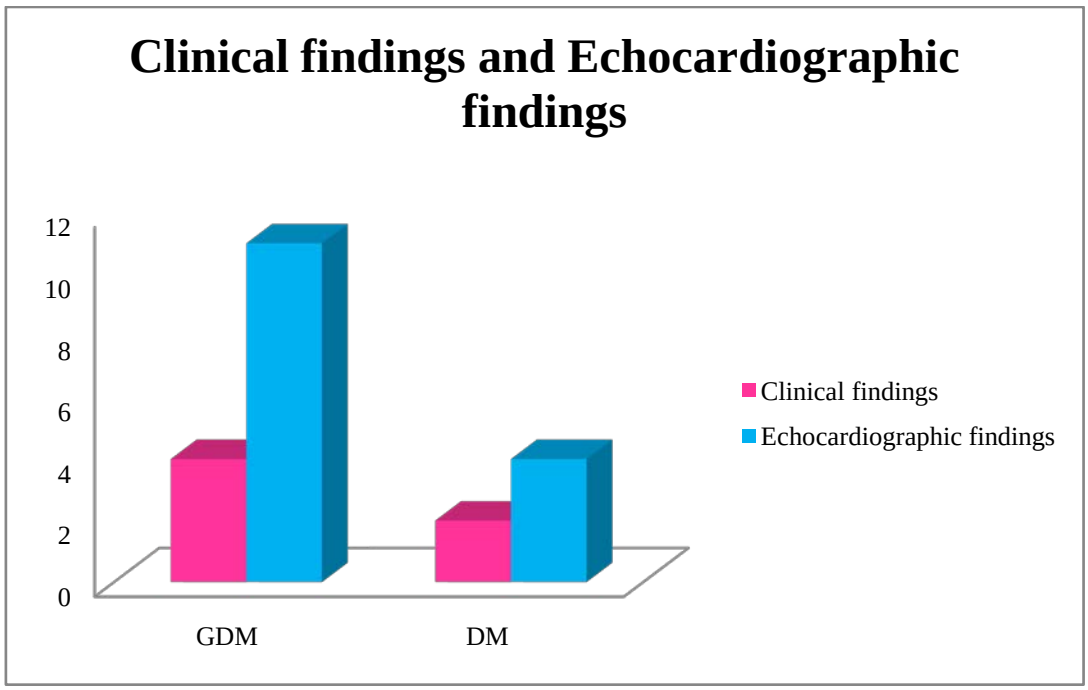
INFERENCE

Since the significance (2 tail) >0.05 there exist no correlation between the birth weight and the presence of heart disease (Both ACHD and CHD).

6.7. Clinical findings and Echocardiographic findings :

Clinical findings		Echocardiographic findings	
GDM	**DM**	**GDM**	**DM**
4	2	11	4
8%	4%	22%	8%

- Among the 50 babies studied 4 (8%) of infants of GDM had clinical findings, 11 (22%) had Echocardiographic findings.
- 2(4%) of infants of pre gestational diabetes mellitus had clinical findings and 4(8%) had echocardiographic findings.
- 12% of babies had clinical findings and 30% babies had echocardiographic findings.



Correlation is significant at the point 0.01 level (2 tailed)

2-tailed significance - 0.00

INFERENCE :

- There is a significant relationship between the clinical identification and the output of the echo.
- Subjects who were clinically identified to have the heart disease were more likely to have a positive echo finding than the others.
- There is a positive correlation between the clinical identification and the positive echo output. Presence of positive clinical identification increases the chance of positive echo findings by 56.4%.

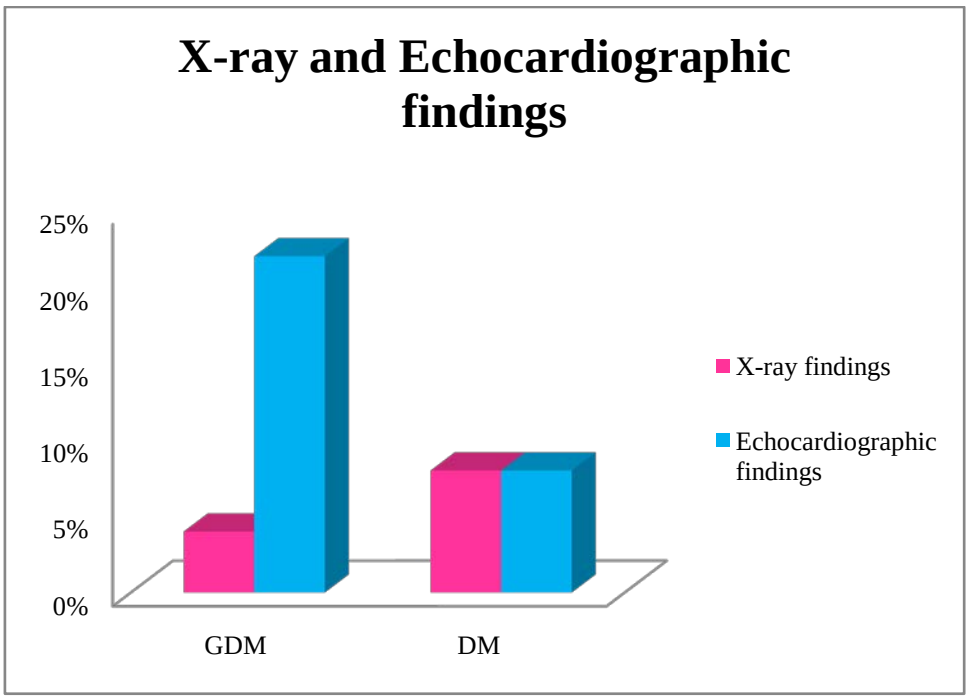
6.8. X-ray and Echocardiographic findings :

X-ray findings		Echocardiographic findings	
GDM	**DM**	**GDM**	**DM**
2	4	11	4
4%	8%	22%	8%

- Among the 50 babies studied 2 (4%) of infants of GDM had X-ray findings, 11 (22%) had Echocardiographic findings.

- 4 (8%) of infants of pre gestational diabetes mellitus had X-ray findings and 4(8%) had echocardiographic findings.

- 12% of babies had X-ray findings and 30% babies had echocardiographic findings.



Correlation is significant at the point 0.01 level (2 tailed)

(2-tailed significance - 0.00).

There exist a relationship between the positive X-ray output and the Echo findings. The subjects who were diagnosed with positive X-ray findings were more likely to have positive Echo findings than those who do not.

There is a positive correlation between the positive X-ray output and positive Echo findings. The presence of positive X-ray findings will increase the chance of positive Echo findings by 56.4%.

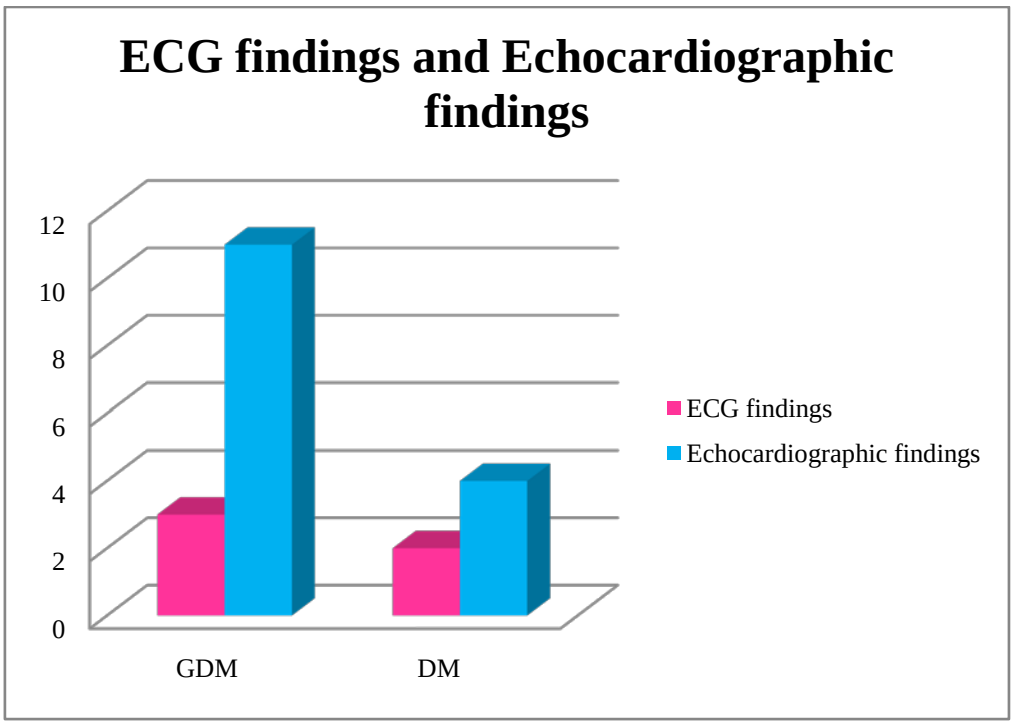
6.9. ECG findings and Echocardiographic findings

ECG findings		Echocardiographic findings	
GDM	**DM**	**GDM**	**DM**
3	2	11	4
6%	4%	22%	8%

- Among the 50 babies studied 3 (6%) of infants of GDM had ECG findings, 11 (22%) had Echocardiographic findings.

- 2 (4%) of infants of pre gestational diabetes mellitus had ECG findings and 4(8%) had echocardiographic findings.

- 12% of babies had ECG findings and 30% babies had echocardiographic findings.



Correlation is significant at the point 0.01 level (2 tailed)

(2-tailed significance - 0.00).

There exist a relationship between the positive ECG output and the Echo findings. The subjects who were diagnosed with positive ECG findings were more likely to have positive Echo findings than those who do not.

There is a positive correlation between the ECG output and positive Echo findings. The presence of positive ECG findings will increase the chance of positive Echo findings by 50.9%.

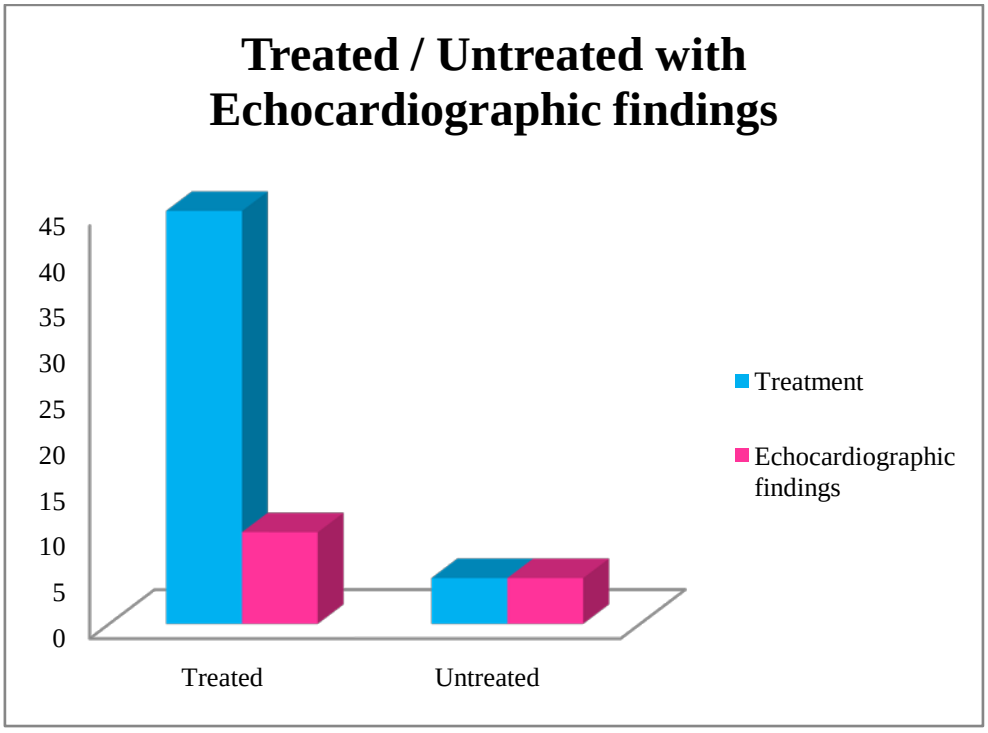
6.10. Treated / Untreated with Echocardiographic findings :

Treatment		Echocardiographic findings	
Treated	**Untreated**	**Treated**	**Untreated**
45	5	10	5
90%	10%	20%	10%

- In this study involving 50 diabetic mothers 45 (90%) were treated and 5 (10%) were untreated.

- Among the treated Echocardiographic findings were positive in 10 (20%) and Echocardiographic findings were positive in 5 (10%) of untreated.

- All the untreated mothers had infants with Echocardiographic findings suggestive for congenital heart disease.



Correlation is significant 0.01 level (2-tailed).

2-tailed significance is 0.009.

INTERPRETATION

There is a significant difference in the occurrence of positive in the Echo findings and treatment. The untreated cases or more likely to have a positive echo findings than the treated cases.

According to the correlation analysis the treatment would decrease the occurrence of positive in Echo findings by 36.4%.

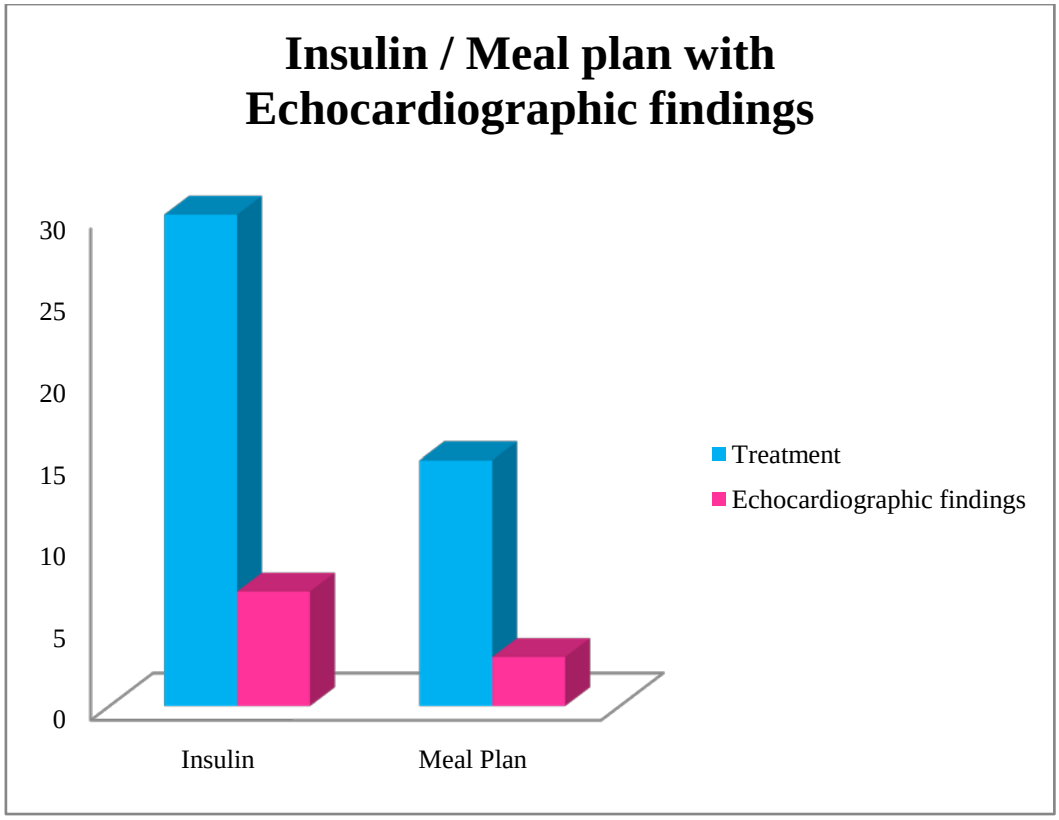
6.11. Insulin / Meal plan with Echocardiographic findings

Treatment		Echocardiographic findings	
Insulin	**Meal Plan**	**Insulin**	**Meal Plan**
30	15	7	3
60%	30%	14%	6%

- Among the 50 diabetic mothers 30(60%) were on insulin and 15 (30%) were on meal plan.

- Positive echocardiographic findings 7(14%) were seen in mothers on insulin.

- Positive echocardiographic findings 3 (6%) were seen in mothers on meal plan.



Correlation is significant 0.01 level (2-tailed).

2-tailed significance is 0.216.

INTERPRETATION

- There is no significance in the occurrence of positive in Echo findings of the group with insulin and the group with meal plan.

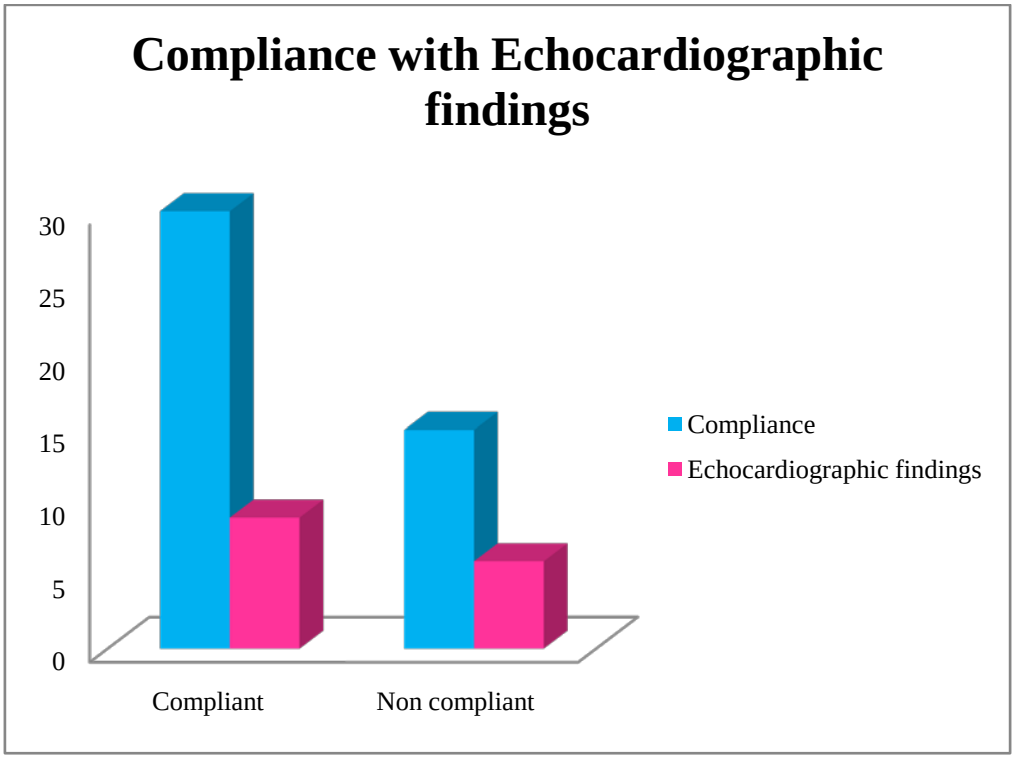
- Thus the insulin or the meal factor has no relationship with the positive outcome of the Echo.

- According to the correlation analysis the output of the Echo has no significant correlation with the insulin or meal plan.

6.12. Compliance with Echocardiographic findings

Compliance		Echocardiographic findings	
Compliant	**Non compliant**	**Compliant**	**Non compliant**
30	15	9	6
60%	30%	18%	12%

- Among the treated mothers 30(60%) were compliant to therapy and 15(30%) were non compliant.
- 9(18%) of echo positivity were seen in compliant mothers.
- 6(12%) of echo positivity were seen in non compliant mothers.



Correlation is significant 0.01 level (2-tailed).

2-tailed significance is 0.090.

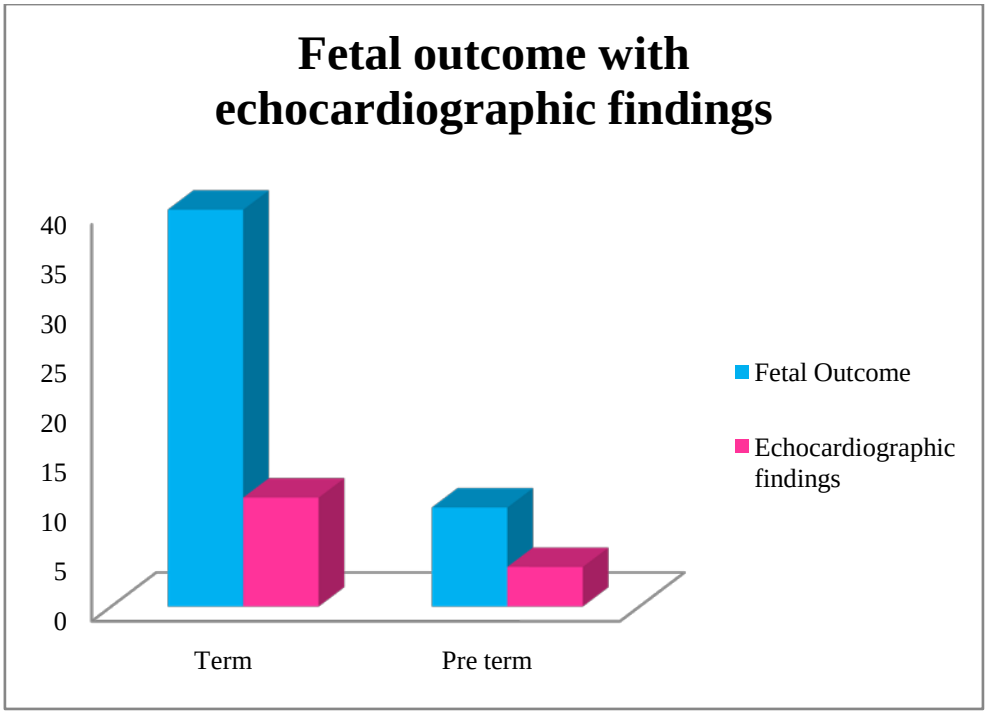
- There is no significant difference in the occurrence of positive in Echo finding between the compliant cases and non compliant cases.

- Thus compliance has no relationship with the output of echocardiographic findings.

6.13. Fetal outcome with echocardiographic findings

Fetal Outcome		Echocardiographic findings	
Term	**Pre term**	**Term**	**Pre term**
40	10	11	4
80%	20%	22%	8%

- Among the 50 babies in this study 40(80%) were term babies and 10(20%) were pre term babies.
- Among the term babies 11(22%) had positive echocardiographic findings.
- Among the pre term babies 4(8%) had positive echocardiographic findings.



Correlation is significant 0.01 levels (2-tailed).

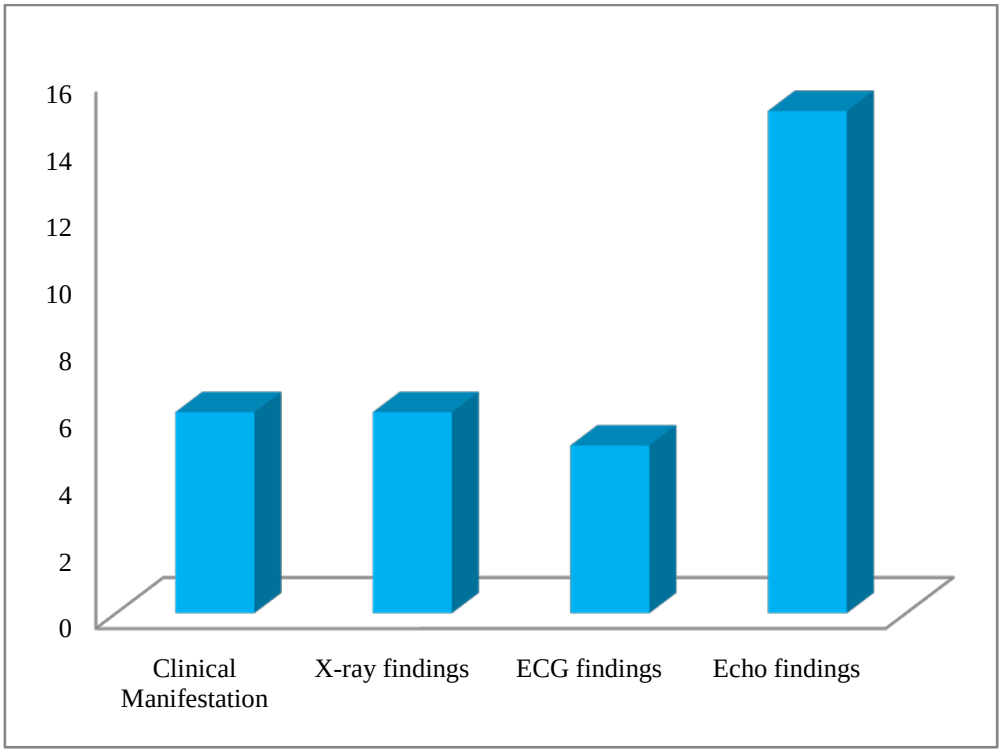
2-tailed significance is 1.000.

- There is no significant difference in the echo findings of term and preterm babies. Thus there is no relationship between the echo findings and fetal outcome.

6.14. Clinical Manifestation, X-ray findings, ECG findings, Echo findings :

	Frequency	Percentage
Clinical Manifestation	6	12%
X-ray findings	6	12%
ECG findings	5	10%
Echo findings	15	30%

- Among the 50 babies studied 6(12%) had positive cardiovascular clinical findings.
- Among the 50 babies studied 6(12%) had positive radiological findings.
- Among the 50 babies studied 5(10%) had positive electrocardiographic findings.
- Among the 50 babies studied 15(30%) had positive echocardiographic findings.



- Presence of positive clinical identification increases the positivity of congenital heart disease by 56.4%.

- Presence of positive radiographic findings increases the positivity of congenital heart disease by 56.4%.

- Presence of positive electrocardiographic findings increases the positivity of congenital heart disease by 50.9%.

- Presence of positive echocardiographic findings increases the positivity of congenital heart disease by 100%.

7. DISCUSSION

Diabetes mellitus complicating pregnancy is an emerging global problem. The progression of the disease is in an increasing trend. Among the pregnancies which are complicated by diabetes mellitus 80% of the cases are contributed by gestational diabetes mellitus and 20% of patients are contributed by pre gestational diabetes mellitus.

The complications occurring in diabetic mothers and their offsprings are unique. Among them the most important complication is congenital heart disease occurring in infants of diabetic mothers.

The treating pediatrician should be familiar about the methods of diagnosing congenital heart disease at an earlier stage for better outcome.

Here an attempt was made to describe the pattern of cardiac complications occurring in infants of diabetic mothers, to emphasize the need for echocardiography in all infants of diabetic mothers for cardiac evaluation.

A total of 50 infants of diabetic mothers born at Tirunelveli Medical College Hospital during the study period of Six months were analyzed.

Physical examination with special emphasis to cardiovascular system along with radiological investigations like X-ray, electrocardiography and higher investigations like echocardiography were performed.

The cardiac complications in new born delivered by gestational diabetes mellitus and pre gestational diabetes mellitus were analyzed. All babies in this study underwent echocardiography before day ten of life.

7.1. Gestational Diabetes Mellitus and Diabetes Mellitus

In almost all the studies performed the percentage of gestational diabetes mellitus mothers outnumbered the pre gestational diabetes mellitus mothers. My studies also reveal the same.

STUDIES	GDM	DM
Kavita et al [28]	64.8%	35.1%
Bhanerjee et al [27]	73.3%	26.6%
Arumugam et al [26]	92.7%	7.3%
My Study	84%	16%

7.2. Sex

In this study among the babies born 54% were male babies and 46% were female babies. There was no difference in occurrence of cardiac disorders between boys and girls.

7.3. Treatment

In this study among the 50 mothers 90% were treated and 10% were untreated. Among the treated 60% of the mothers were on insulin and 30% of mothers were on meal plan.

7.4. Compliance

Among the mothers on treatment 60% of the mothers were compliant to therapy and 30% of mothers were non compliant to the treatment. This shows the many number of antenatal mothers are on regular checkup with proper treatment and most of them were compliant in their treatment.

This is similar to a study conducted at Karachi during the period of August 1999 to January 2005 by Alam et al in The National Institute of Child Health Karachi.

Among them 12.5% had diabetic diet, 47.5% had insulin therapy and 40% of mothers were untreated.

There is a significant difference between the occurrence of positive echocardiographic findings and the treatment. Untreated mothers had more number of infants with congenital heart diseases than mothers on treatment.

7.5. Mode of delivery

In this study 54% of babies were delivered by LSCS, 46% of babies by normal labour.

In a study conducted by Alam et al 55% of babies were delivered by LSCS whereas 45% of babies were delivered by normal labour. This is comparable with my present study.

7.6. Fetal outcome Term / Preterm

In this present study 80% of babies were delivered as term babies whereas 20% of babies were delivered as preterm babies. This is comparable with the studies mentioned below.

Studies	Preterm	Term
Gethu et al	75.0%	25.0%
Abdhul Bari et al [30]	79.1%	20.0%
Aklagi et al [29]	70.6%	29.4%
My Study	80%	20%

There is no significant difference in congenital heart disease between term and preterm babies. There was no significant relationship between echo findings and fetal outcome.

7.7. Cardiac Outcome

Among the 50 babies studied 12% babies showed clinical manifestations of underlying congenital heart disease, 12% of babies showed radiological abnormalities and 10% of babies showed electrocardiographic abnormalities. Echocardiographic changes were found in 30% of babies.

Among the 50 babies 26% of babies were found to have Acyanotic congenital heart disease and 4% of babies were found to have congenital cyanotic heart disease. Cardiac lesions encountered by me were

Heart Disease	Frequency	Percentage
Hypertrophic Obstructive Cardiomyopathy	5	10%
Atrial Septal defect	2	4%
Ventricular Septal Defect	2	4%
Patent Ductus Arteriosus	2	4%
Patent Foramen Ovale	2	4%
Transposition of Great Vessels	1	2%
Tetrology Of Fallot	1	2%

Most common heart diseases encountered were Hypertrophic Obstructive Cardiomyopathy, Ventricular Septal Defect, Patent Ductus Arteriosus, Atrial Septal defect (Ostium seccundum) and Patent Foramen Ovale.

Cyanotic heart diseases like Transposition of Great Vessels, Tetrology of Fallot were encountered.

Complex heart diseases like hypoplastic left heart syndrome, coarctation of aorta, truncus arteriosus, and Aortic stenosis were not encountered in this study.

Similar study was performed by Abu Sulaiman et al [25], Subaih et al at King Khalid University Hospital at Riyadh.

The most common heart diseases encountered by them were

PDA = 70%

PFO = 68%

HOCM = 38%

ASD = 5%

VSD = 4%

MVP = 2%

PS = 1%

Severe forms of heart diseases like

TGV

TOF

Hypoplastic left heart syndrome were also encountered.

The higher occurrence of congenital heart diseases is due to the detection of minor forms of congenital heart diseases by echocardiography which were not detected by routine physical examination after birth and during infancy.

Cases which were not detected by clinical examination, radiological investigation, and electrocardiography were detected by echocardiography.

- Clinical manifestations were positive in 56.4% of the cases with congenital heart disease.
- Radiological investigations were positive in 56.4% of the cases with congenital heart disease.
- Electrocardiographic findings were positive in 50.9% of the cases with congenital heart disease.
- Echocardiography was positive in 100% of the cases with congenital heart disease.

Echocardiography remains the gold standard investigation for the diagnosis of congenital heart diseases in infants of diabetic mothers.

Hence all infants of diabetic mothers must undergo echocardiographic investigation before their discharge for earlier diagnosis and appropriate management of congenital heart diseases.

8. LIMITATIONS OF STUDY

- Intrauterine deaths, abortions, still birth were not taken into account in this study.

- Infants of diabetic mothers with severe birth asphyxia with APGAR score <3 at 5 min were not included in this study due to infrequent association of transient myocardial ischemia which may present as systolic murmur.

- The sample size used in this study is small so it was difficult to establish the wide spectrum of cardiac disorders manifested by infants of diabetic mothers.

9. CONCLUSION

Gestational diabetes mellitus is much more common than pre gestational diabetes mellitus. The new borns included in the present study had significant number of cardiac complications. Cesarean deliveries were common among mothers of diabetes mellitus.

There were no sex preponderance for incidence of heart diseases. Infants of diabetic mothers were usually associated with metabolic complications and various congenital anomalies. Hence they should be admitted for close monitoring.

The cardiac complications can be diagnosed earlier by antenatal echocardiography.

Careful physical examination with special emphasis to the cardio vascular system by performing detailed clinical examination, radiological investigation with X-ray, eletrocardiography, echocardiography can detect congenital heart diseases at an earlier stage.

Mothers on regular treatment had lesser incidence of congenital heart diseases than untreated mothers.

Echocardiography remains the gold standard tool for the diagnosis of congenital heart diseases in infants of diabetic mothers. Infants of

diabetic mothers must undergo echocardiography as a routine as early as possible.

Earlier recognition, precise assessment of the cardiac status and appropriate management of cardiac complications might reduce both the morbidity and mortality among babies born to diabetic mothers.

10. ANNEXURE

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PROFORMA

Name :

Age / Sex :

Address :

Antenatal Details :

Married Since :

Consanguinity :

Conceptional Age :

Parity :

Previous IUD / Abortion / Still birth :

Registered / Not registered :

Pregnancy confirmation :

Immunisation :

Gestational Diabetes Mellitus / Pre Gestational Diabetes Mellitus :

Time of diagnosis :

Treatment Details :

Compliance :

Natal Details :

Mode of delivery :

Normal labour / Forceps / Vaccum / Emergency LSCS / Elective LSCS.

Place of Delivery :

Liquor - Clear / Meconium stained :

Birth injuries :

Perinatal hypoxia :

Fetal outcome - Abortions / IUD / Still born / Term delivery / Preterm delivery.

Clinical Examination of new born :

Birth weight :

AGA / SGA / LGA :

IUGR :

Head circumference :

Chest circumference :

Oesophageal patency :

Anal patency :

Caput / Cephalhematoma / Subgaleal Bleed :

Birth injuries :

Congenital Anomalies :

General appearance :

Alert / Drowsy :

Respiratory Distress :

Icterus / Cyanosis / Plethora :

Cardiovascular system examination :

Position of apical impulse :

Heart rate :

Cyanosis :

Systolic murmur :

Increased precordial activity :

Congestive cardiac failure :

Shock :

Lab investigations

Mother :

FBS :

PPBS :

CBG monitoring in new born :

X-Ray :

ECG :

Echo :

MASTER CHART

S. NO	Name	Sex	Booked/ Unbooked	GDM/ DM	Treated / Untreated	Insulin/ Meal	Compliance	Delivery	Fetal Out come	Weight in Kg	ACHD/ CHD	Clinical	X-ray	ECG	Echo	Shock / CCF
1	B/o Meenatchi	M	B	G	T	I	C	L	T	4.2	-	-	-	-	-	-
2	B/o Peratchi	M	B	G	T	I	C	L	T	2.9	-	-	-	-	-	-
3	B/o Deepa	F	B	G	T	I	C	L	T	4.4	-	-	-	-	-	-
4	B/o Sudalai	M	B	G	T	M	N	L	T	4	A	-	-	-	HOCM	-
5	B/o Veni	M	B	D	T	I	C	N	T	3.1	-	-	-	-	-	-
6	B/o Rani	M	UB	G	-	-	-	N	P	2.4	A	-	+	-	HOCM	-
7	B/o Malathi	F	B	G	T	M	N	N	T	4.22	-	-	-	-	-	-
8	B/o Kasthurai	F	B	G	T	M	N	L	T	3.5	-	-	-	-	-	-
9	B/o Jenifer	F	B	D	T	I	C	N	T	4.2	A	+	+	+	VSD	-
10	B/o Ranjani	F	B	G	T	I	N	N	T	3.4	-	-	-	-	-	-
11	B/o Jenitha	M	B	G	T	I	C	N	T	2.87	-	-	-	-	-	-
12	B/o Kala	M	B	G	T	I	C	L	P	2.3	-	-	-	-	-	-
13	B/o Mani	M	B	D	T	I	C	L	T	4.4	-	-	-	-	-	-
14	B/oVanitha	M	UB	G	-	-	-	L	T	4.2	A	-	+	-	HOCM	-
15	B/o Seetha	M	B	G	T	I	N	N	T	3.3	C	+	-	-	TOF	-
16	B/o Prema	F	B	G	T	I	N	N	T	2.5	-	-	-	-	-	-
17	B/o Bhavani	M	B	G	T	M	C	L	P	2.6	-	-	-	-	-	-
18	B/o Savitiri	F	B	D	T	I	C	L	P	2.2	-	-	-	-	-	-
19	B/o Saweetha	F	B	D	T	I	C	L	T	2.3	-	-	-	-	-	-
20	B/o Nazeema	F	B	G	T	I	C	L	T	2.8	A	+	-	-	PDA	-
21	B/o Jasimine	M	UB	G	-	-	-	L	P	2.4	-	-	-	-	-	-
22	B/o Chitra	M	B	G	T	I	N	L	P	2.3	A	-	-	-	PFO	-
23	B/o Ratna	M	B	G	T	I	N	L	T	2.35	A	-	-	-	PFO	-
24	B/o Maina	F	B	G	T	I	C	N	T	4.15	-	-	-	-	-	-
25	B/o Raji	F	B	G	T	I	C	N	P	3.3	-	-	-	-	-	-

S. NO	Name	Sex	Booked/ Unbooked	GDM/ DM	Treated / Untreated	Insulin/ Meal	Compliance	Delivery	Fetal Out come	Weight in Kg	ACHD/ CHD	Clinical	X-ray	ECG	Echo	Shock / CCF
26	B/o Gowri	F	B	G	T	I	C	L	T	3.4	-	-	-	-	-	-
27	B/o Subbu	M	B	G	T	M	C	L	T	3.5	-	-	-	-	-	-
28	B/o Annam	M	B	G	T	M	C	N	T	4.3	-	-	-	-	-	-
29	B/o Latiha	M	B	G	T	M	C	N	T	3.4	-	-	-	-	-	-
30	B/o Jeyanthi	M	B	D	T	M	C	N	T	4.3	A	-	+		HOCM	-
31	B/o Nandini	M	UB	G	-	-	-	L	T	4.1	A	-	-	+	ASD	-
32	B/o Divya	F	B	G	T	M	C	L	T	3	-	-	-	-	-	-
33	B/o Kamala	M	B	G	T	M	C	N	P	2.4	C	+	-	-	TGV	-
34	B/o Rathinam	M	B	G	T	M	C	L	T	3.1	-	-	-	-	-	-
35	B/o Gracy	M	B	G	T	I	N	N	T	2.9	-	-	-	-	-	-
36	B/o Selvi	F	B	G	T	I	N	N	T	4.1	A	-	-	+	ASD	-
37	B/o Angella	M	B	G	T	I	C	L	T	2.75	-	-	-	-	-	-
38	B/o Esaki	F	B	G	T	M	C	L	T	3.7	A	+	-	-	PDA	-
39	B/o Manju	M	B	G	T	M	N	L	T	4.4	-	-	-	-	-	-
40	B/o Muthu	M	B	D	T	I	C	L	T	4.3	-	-	-	-	-	-
41	B/o Kani sree	F	B	G	T	I	N	N	P	2.3	-	-	-	-	-	-
42	B/o Valli	F	B	G	T	I	N	N	T	3	-	-	-	-	-	-
43	B/o Rathi	F	UB	G	-	-	-	N	T	4.2	A	-	+	+	HOCM	-
44	B/o Kalli	M	B	G	T	I	C	N	T	3.7	-	-	-	-	-	-
45	B/o Stella	F	B	G	T	I	C	N	T	3.2	-	-	-	-	-	-
46	B/o Malli	F	B	G	T	M	N	N	P	2.3	-	-	-	-	-	-
47	B/o Fathima	F	B	G	T	I	C	L	T	4	-	-	-	-	-	-
48	B/o Arthi	F	B	G	T	M	C	L	T	4.2	-	-	-	-	-	-
49	B/o Visalatchi	M	B	D	T	I	C	L	T	4.1	-	-	-	-	-	-
50	B/o Jancy	F	B	G	T	I	N	N	T	4.5	A	+	+	+	VSD	-